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Editor, DEVELOPMENT DIGEST
National Planning Association
1525 18th Street, N. W.
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DEVELOPMENT DIGEST

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Frances M. Geiger, Editor ad interim,
Pushpa Nand Schwartz, Associate Editor
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UNEMPLOYMENT

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(ILO PANORAMA, NO. 35, MARCH-APRIL 1969, P. 7.
PHOTO: INTERNATIONAL LABOR OFFICE.)

The Employment Problem

United Nations Economic
and Social Council

[Creating sufficient jobs to absorb not only those presently unemployed but also the increasing numbers reaching working age in the coming decade will be extremely difficult in the developing countries. New approaches to increase both labor intensity and output in urban and rural activities are suggested.]

No matter what changes take place in birth rates, developing countries are going to be faced with a dramatic increase in the numbers of young people seeking some form of gainful employment in the course of the coming decade. The population of working age is presently growing at an annual rate of about 2.3 percent; and in the 1970s, this rate will accelerate to nearly 2.7 percent. This trend is irreversible, and the problems which it creates are inescapable.

Comparison with the developed countries may help to emphasize the rapidity of the expected increase. Their working age population is projected to grow by about 1 percent per annum in the 1970s; and in the developed centrally planned economies approximately 1.2 percent. Thus, the labor force in developing regions will grow at a rate two to three times as great.

While the continued growth of total output will progressively enlarge the number of employment opportunities, economic growth is always associated with technological and structural changes that raise labor productivity; and employment consequently increases at a slower pace than output. Labor productivity in developing countries may be expected to rise at a rate somewhere in the range of 2 to 4 percent per annum. Thus, if their projected annual increase in the labor

force over the next decade is to be absorbed into employment, the annual rate of increase in gross domestic product will have to be in the range of 5 to 7 percent. The problem is compounded by the widespread unemployment and underemployment that now prevails. Employment opportunities must increase not only to absorb the additions to the labor force but also to reduce the present unemployment.

It is well-nigh impossible to make any statistical assessment of the extent of present unemployment and underemployment. Indeed, it is even conceptually difficult to define. The conventional measurements used in developed countries are of very limited relevance in predominantly agrarian economies, since these rely on the prevalence of wage employment and a standard work week. In developing countries, most of the working population finds some sort of livelihood in agriculture or services where, as is well known, many are idle or underemployed for much of the time. Idleness, or underemployment, may not always be involuntary; in many rural areas the accepted, traditional pattern of social behavior largely limits economic activity to short periods of intensive work during the planting and harvesting seasons; and the long non-productive stretches are not so much enforced idleness as a part of the traditional life. Nevertheless underemployment, in the sense of the numbers of people willing to work longer and harder to improve their lot but without the opportunity to do so, is spreading quite rapidly.

Some estimates for individual countries and a region may be quoted to illustrate possible orders of magnitude. In the Third Plan of Pakistan, for instance, it was noted that "almost one fifth of the available manpower... is wasted every year for lack of useful work. Unemployment in Pakistan generally takes the form of an underutilization of at least half of the available manpower." The Fourth Plan in India noted that "the backlog of unemployment at the beginning of the Fourth Plan is 9 to 10 million, of whom about three fourths are in the rural areas." It further estimated that: "... against the 23 million of net addition to the labor force during the period of the Fourth Plan, the increase in employment opportunities outside agriculture may be about 14 million and in agriculture of the order of 4.5 to 5 million, making a total employment potential of 18.5 to 19 million." Thus unemployment is estimated to increase by about 4 to 4.5 million to a total of 13 to 14.5 million. For Latin America as a whole, the Economic Commission for Latin America has estimated that about 40 percent of the economically active labor force was underemployed in 1960. A calculation of overall unemployment, in which underemployment was reduced to its unemployment equivalent, showed that about 18 million persons—or some 27 percent of the active population—were unemployed in 1960. In order to absorb those now underemployed as well as the new additions to the active labor force, total output would have to

grow by not less than 8 percent per annum in 1970-80; increases of 6 percent per annum would preserve the 1960 level of unemployment into 1980.

The conclusion can hardly be avoided that the task of creating sufficient employment opportunities over the next decade both to absorb the growing labor force and to lessen underemployment, is likely to be beyond the capacity of many developing countries. Though much of the underemployment will remain dispersed—concealed—throughout the rural areas and in the service industries, the pool of open urban unemployment, with all its attendant social ills and tensions, will surely swell.

Past Approaches

Numerous governments in developing countries have been deeply concerned about this problem for some time. Many have for years carried out programs of a public works nature specifically intended to alleviate unemployment in urban and rural areas. Youth corps or youth training schemes have also been widely developed in an attempt to stem the rising tide of unemployment among school-leavers. However socially desirable and often politically imperative, these various public works programs have necessarily been limited in scope by financial and organizational constraints. Besides being only temporary palliatives, their contribution towards improving the employment situation has generally been modest; and by themselves, they cannot offer a general solution to the problem.

The growth of employment depends on developments throughout the economy as a whole, and the principal measures to promote employment must be correspondingly broad-based. The main prescription for the employment problem offered in the earlier post-war years was capital accumulation; industrial growth, in particular, was believed to be the primary solution for the generation of higher levels of employment. In developed countries where employment levels are high, a large proportion of the working population is in industry and a small proportion in agriculture, whereas in developing countries the position is quite the reverse. It was concluded, therefore, that the solution for developing countries lay in a rapid transfer of their working populations from the traditional agricultural sector to the modern industrial sector. Actual experience over the post-war years, however, has demonstrated that industry emerges as a major source of employment only after a long period of growth. Though numerous developing countries have made progress in industrialization, the proportion of the working population employed in industry has generally risen only moderately, and the absolute numbers engaged in agriculture have invariably continued to increase. (Even in Japan, agricultural workers increased until the mid-1950s.)

While no one would deny the underlying importance of capital accumulation for the creation of employment, the forces determining the growth in employment cannot be simply explained in terms of the aggregate level of new investment. With the emphasis in development theory and practice on capital accumulation, however, alternative strategies for raising the level of employment and output have not played any central part in policy discussions. Employment is still regarded mainly as a resultant of development policies and programs designed to influence the level and pattern of investment. Alternatively, it is viewed as a social objective which, though it may require measures like a public works program to lessen suffering or unrest, stands in conflict with the aim of greater output. The possibilities of raising output through increasing the degree of labor utilization have thus been largely neglected.

In view of the gravity of the problem of unemployment, there is need for re-examination of the prevailing position. Two alternative approaches are discussed below.

Labor-Intensive Methods

The use of labor-intensive methods of production has provoked much discussion among economists as an approach to the employment problem. It is contended that, since developing countries have a greater supply of labor relative to capital than developed countries, the former should use more labor-intensive techniques. Such substitution of labor for capital would make greater use of the available labor force and result in greater total output than would otherwise be possible.

The theoretical grounds for this view have been thoroughly explored, and are well established. However, the view has not fared well in the arena of practical affairs. It has been widely misunderstood to imply that developing countries should eschew the technologically more advanced and larger-scale industries, since these are usually more capital-intensive. While many governments and institutions have favored the use of labor-intensive methods in their statements of policy, the influence of these statements on actual decisions has been generally slight.

The choice of techniques is subject to major restrictions because the composition of output cannot be decided on the basis of the relative scarcity of capital and labor, but must conform to the pattern of demand in domestic or export markets; and within the branches of production required to meet demand, technical conditions may limit the possibilities of substitution. Moreover, the reduction of productive resources to two factors—capital and labor—each considered as homogeneous, is a broad simplification which may not hold

in reality; they are far from homogeneous, and relative costs of other inputs may also be germane to the choice of technique. In practice technological conditions may either narrow or eliminate choices or make a capital-intensive method preferable on the grounds of quality control, or reduction in wastage of materials. For such reasons, the necessary and rational choice for developing countries to make is very often a decision favoring capital-intensive factories incorporating the most modern technology. But, within recognized limitations, some possibilities for substitution of labor for capital do exist.

Foreign trade offers a partial escape from the limits imposed by the small size of domestic demand on the choice of industries. Production in labor-intensive industries can be expanded beyond domestic requirements if export markets can be found, and many commentators urge the developing countries to concentrate on labor-intensive industries. It is probably a reasonable presumption that for countries where wage-costs are relatively low, the greater comparative advantages in international trade may lie in the labor-intensive industries. On a realistic view, however, their potential contribution to alleviation of the employment problem must usually be very limited. The size of the sector producing exportable manufactures is generally a very small segment of the national economy in developing countries. Moreover, relative capital and labor costs alone do not determine comparative advantage; costs of the materials and semi-manufactures used in the production process are also significant, and these vary with natural resource endowment and stage of development. Finally, the creating of export markets for manufactures presents considerable, well-known difficulties; developing countries often lack the supporting marketing and credit structure necessary to compete effectively in world markets and counter the trade obstacles to sales in developed countries.

In production for the domestic market, there may be greater possibilities for promoting the use of labor-intensive methods. Not all industries or branches of production are technologically inflexible—e.g., weaving, clothing, woodworking, leather, construction materials and most of the simpler metal products. Opportunities for labor absorption and capital saving also exist in manufacturing processes in various ancillary operations, such as materials handling and packaging. The construction industry and agriculture also offer scope for the substitution of labor for capital; many of the necessary activities can be performed either by manual labor or by labor-saving machinery.

Anti-Labor Bias

There is probably considerable scope in most developing countries for the greater use of labor-intensive methods in numerous branches of production. It seems quite evident that both the structure of prices and the adoption of technologies from developed countries tend to bias investment decisions unduly in favor of capital-intensive methods. The practical means of correcting this bias in the conditions of mixed or market economies have not been worked out in any coherent way, however.

Governments might review their present tax, tariff and credit policies in order to determine whether these tend to bias investment decisions against labor-intensive methods. For instance, tax concessions widely offered to new private investors, and comparable tariff concessions on imported capital equipment, are generally designed to lower capital costs in order to stimulate private investment. The concessions either contain some bias against labor-intensive methods, as in the case of accelerated depreciation allowances, or are neutral between capital saving and labor-saving methods, as with most tariff concessions. Changes in the nature and administration of the concessions could be introduced which would tilt investment decisions more favorably towards labor-intensive methods. Similarly, public agencies extending investment credits to the private sector could be enjoined from offering loans for labor-saving equipment on the same terms as for other equipment.

In their own investment programs, governments are not bound to adhere as rigidly to the dictates of market prices in their choice of techniques. Moreover, they usually play a commanding role in construction activity such as roads and irrigation projects. Financial resources may limit the extent to which the more costly labor-using methods can be preferred to capital-using methods. At the same time it is clearly more advantageous to seek to absorb labor through approved investment programs than to carry out these programs through capital-intensive methods and later be faced with the necessity of mounting additional public works programs specifically for generating employment. On the whole, however, governments do not seem to have tried to follow this prescription in their investment programs in any systematic way. The technical departments of government usually have a strong bias in favor of using capital-intensive methods for several reasons: besides saving on departmental budgetary costs, these methods minimize problems of labor organization. High technical standards for the quality of the project, attainable only through the use of machinery, are sometimes also set, often only because they are in line with the latest practices in developed countries; this tendency may be particularly strong when overseas consultant firms or contractors are employed on the project.

Foreign lending agencies also reinforce the tendency, since they are usually insistent on minimizing the financial cost. Aid-donor governments and agencies could make some contribution towards the greater utilization of labor if they broadened their loan conditions to include this consideration.

Finally, attention should be drawn to the importance of training for the promotion of labor-intensive methods. This includes training both in skills and in labor management and organization. The preference for capital-intensive methods in both the public and the private sectors quite often arises from the shortage of skilled labor and, perhaps more important, from the reluctance of employers to recruit a labor force which would not only need on-the-job training but may also be without much previous experience in regular, wage employment. Through the use of machinery, the difficulties encountered in the organization of training and in the development of disciplined work habits are avoided. Governments can counter this tendency by encouraging on-the-job training and enlisting the support of management and unions in improving the organization of work forces. In their own investment programs, they clearly have a particular responsibility to face, and deal with, these difficulties.

Employment in Agriculture

Another approach to the problem of employment is to increase the degree of labor utilization in agriculture through broad changes, mainly of an institutional and organizational character. In past discussions of development, the large labor supply in many developing countries has been viewed as a surplus of productive resources which could be used to raise output by transferring labor out of agriculture to industry or to special projects in the rural areas. The assumption was that withdrawal of labor from agriculture would not reduce total agricultural output, since there was widespread underemployment in agriculture and the productivity of labor at the margin was negligible, or even zero.

This theory, however, does not seem to square with the evidence. Despite the mass underemployment and low productivity, it is questionable whether a large pool of surplus labor, freely transferable to other sectors without loss of agricultural output, is a reasonable, working hypothesis. In the traditional, and largely subsistence, economy which prevails in rural areas, output is related mainly to subsistence requirements and is shared by those who, in one way or another, take part in the process of production. The family is not only the social unit, but also the fundamental economic entity for the organization of work and the distribution of output. The motivation to raise output above the accepted subsistence level may be weak because the traditional pattern of life places a high value on leisure

or non-economic activities; the incentive to raise output may be largely stifled by an institutional structure which attenuates the relation between productive effort and reward; and even where the incentives and motivation are present, the knowledge and the means for raising output through the use of improved inputs, different cropping patterns or better husbandry methods may be lacking. Thus, production is decided mainly on the basis of subsistence requirements, the amount of productive effort varying more with the number in the family available for work than with other factors. There is widespread underemployment, but much of it is seasonal and is inherent in the traditional farming practices and way of life.

The same reasons which cast doubt on the existence of a freely transferable labor surplus, however, also point to the possibilities for a more intensive utilization of labor within agriculture through institutional, economic and technical changes.

The size of holdings, the kinds of crops and the methods of cultivation combine to determine the degree of labor utilization. It has been found, for instance, from a study of 19 countries, that output per acre tends to be higher on small holdings than on large farms or estates. Because there are relatively more adult workers depending for their livelihood on the small holding, more labor-intensive methods are likely to be used; although output per man is lower, output per acre may be higher than on the larger holdings. Further, cropping patterns are also likely to vary appreciably with the amount of land and labor available to each farm unit. A study carried out in Chile, for instance, concluded that the labor force on medium-size farms could be increased by 80 percent, and on large farms by 130 percent, if these holdings followed a cropping pattern similar to that found on subsistence family holdings.

These observations appear to argue for the development of a peasant-type rural economy as the most likely means of raising output per unit of land through the more intensive use of labor. For numerous developing countries, this may well be a valid conclusion. However, no dogmatic assertion can be made that a peasant-type economy offers the best solution everywhere. Several forms of farming systems may be capable of fostering both a more intensive utilization of labor and growing agricultural output, depending on the kinds of crops to be grown and the local ecological conditions. Local traditions and attitudes also condition the readiness of the rural population to work within different farming systems. Much of agricultural planning should, in fact, be concerned with the search for a suitable framework within which the technical and the institutional conditions are reconciled. The range of possible variation is wide, running from independent peasant holdings to forms of collective farming under close central direction; and in each country,

different systems may be appropriate for different areas and crops. What matters throughout, however, is that each particular system should promote the growth of output by the more intensive use of labor.

The development of new forms of social and economic organization in agriculture to raise both output and employment is still largely a novel endeavor. In many countries political resistance to institutional reforms blocks the way towards the introduction of new forms. However, a number of countries have been engaged in extremely interesting experiments in recent years. Studies of the relation between farming systems on the one hand, and output and employment on the other, are being more extensively undertaken. In view of the great importance of finding ways of lessening the employment problem, such experiments and studies can surely be of immense value.

[Excerpted from the forthcoming World Economic Survey, 1968, Part I, "Some Issues of Development Policy in the Coming Decade: Population, Employment and Education." New York: United Nations, preliminary edition Document E/4687/Add. 1, 4 June 1969, Chapter I, pp. 7-20.]

Employment in Nigeria

W. Arthur Lewis

[Unemployment in the towns, despite rural labor shortages, is caused by rapid expansion of schooling and excessive income differentials. Increasing opportunities in agriculture are the best hope for reducing unemployment in Nigeria.]

Unemployment is Nigeria's most serious social problem. It is due to the excessive drift away from agricultural employment, mainly by school-leavers, mainly into the towns. One corollary is the coexistence of labor shortage in rural areas with unemployment in the towns. Another corollary is the rapid growth of a few urban centers, faster than amenities can be provided, so that slum conditions are multiplying rapidly.

An industrial revolution, such as Nigeria is now beginning, is always accompanied by a drift from the countryside into the towns. In 19th-century Europe, however, the urban demand for labor and the supply remained more or less in equilibrium, so that urban unemployment tended to decline (relatively to population) rather than to increase. Compared with that experience, the situation in Nigeria is worsened by four principal factors:

1. Faster population growth.
2. The disequilibrating effects of accelerated schooling.
3. The greater gap between rural and urban incomes.
4. The higher capital-intensity of investment.

Dr. Lewis is Professor of Economics and International Affairs at the Woodrow Wilson School of Public and International Affairs, Princeton University, New Jersey.

Educational Levels and Numbers

Schooling as such does not cause migration to the towns: it is the rapid acceleration of schooling which has had this effect. In the days when only 10 percent of children completed a primary education, non-agricultural jobs were available for all of them at incomes considerably in excess of the average farmer's. This set up an expectation that schooling leads to a well-paid non-agricultural job. This expectation can be fulfilled when only 10 percent complete school, but cannot be fulfilled as the completion rate races up twards 50 percent (in the Southern regions). It takes time to alter expectations and the interval is one of painful frustrations.

The gap between urban and rural incomes makes this difficult. Urban incomes are usually up to 50 percent higher than rural incomes, but in Nigeria unskilled urban wages are much more than twice a farmer's income. The vulnerability of the governments, which employ one third of those who work for wages, to trade union demands has been one of the main causes of this (though it is not clear why the politicians, who depended much more on the millions of farm votes than upon the hundred thousands of workers' votes, allowed themselves to be blackmailed). If the gap between urban and rural incomes remains so wide, one must expect the towns to be full of partially employed people, who hope to get by with an average of two or three days' work per week.

The gap has been widened by reducing farm incomes as well as by raising urban wages. In index values the prices paid to Southern farmers by the marketing boards went down from 100 to 73 between 1950-52 and 1961-63, while the minimum wage paid by the federal government to unskilled labor over the same period went up from 100 to 297. One need not look much further to understand why young people drift out of agriculture to seek part-time work in the towns, although there is a shortage of labor in the country and a surplus in the towns. Urban unemployment is bound to continue growing until this deliberate discrimination against farm incomes is ended.

The educational disequilibrium is at present confined mainly to primary school-leavers. At the secondary school level the situation varies from region to region, and even more from district to district. In the North the output is still well below absorptive capacity. Countries at the level of the Southern regions can normally absorb easily graduates of high schools equal to about 5 percent of the age group. The number of fifth formers in the Southern regions is only between 2 and 3 percent of the age group, so there are plenty of jobs for which a secondary education is appropriate. The obstacles are psychological and financial: the expectations of secondary school-leavers need the same sort of readjustment as those of primary

school-leavers. Many occupations now manned largely by primary school-leavers (teachers, nurses, typists, clerks, agricultural assistants, technicians, etc.) will in future be filled mainly by secondary school-leavers, who at present tend to look down on such jobs, and to expect higher pay than these jobs offer. However, an economy absorbs an increasing proportion of secondary school-leavers by upgrading the entry requirements for jobs and reducing the salaries previously paid to secondary school-leavers. The frustrations inherent in readjusting expectations cannot be avoided.

The same frustrations are also beginning to be felt at university level. The normal absorptive capacity of countries at the Southern level would be about 0.5 percent of the age group, or about 2,000 graduates a year. The number of second-year students in the Southern universities in 1963-64 was only 760, but the number graduating abroad may be about the same. The chief obstacle to absorption is the high salary expectation. In Britain a new university graduate is paid about as much as a miner, but in Nigeria a new university graduate expects to be paid as much as four miners or nine farmers. This makes very expensive all the jobs for which university graduates are used and reduces absorptive capacity. At the same time, many university graduates scorn jobs as secondary school teachers because their financial prospects are not as good as those of civil service jobs. Unless there is downward readjustment of the differential between university salaries and the country's average per capita income, Nigeria will soon not be able to use all the graduates who are being trained at public expense. At present university graduates go mostly into government employment; as price relations alter there may be much more scope for them in private enterprise.

The other side of this situation is that the "manpower problem" of skill shortages is rapidly disappearing. The country will soon have as many primary and secondary school-leavers as it can absorb, and given new specialized training institutions, should soon be completely self-sufficient in intermediate skills. At the university level supply is not far short of demand at current prices. But, given adequate alteration of differentials, large new layers of demand could be opened up. One of the ways a community raises its productivity is to get the more educated to do jobs which were previously considered appropriate only to the less educated.

Investment

Nigeria has been investing gross about 15 percent of gross domestic product, but the number of persons employed as a result of this investment is rather small. This phenomenon Nigeria shares with many other developing countries. The reasons are: 1) Wages are high in relation to productivity and to machine costs, so enterprises

are more mechanized than they would otherwise be. 2) With protection from competition by tariffs and licensing, entrepreneurs do not economize capital carefully. Plants are built larger than the demand justifies, or are built as "show-places" at high cost. 3) Manufacturing should expand simultaneously in both large and small scale plants. Instead, there is a gap in Nigeria between the large enterprises (foreign financed, heavily capitalized) and the small enterprises (African and underfinanced). 4) Much public investment is wasteful because of the show-place mentality. Large sums are spent for political prestige reasons on projects which add little employment (e.g., airlines). Each project in the Plan should be required to show how many more persons it will employ.

The employment situation would be helped if investment could be more labor-intensive. Kenya economists report that private real output there increased by 4 percent per year between 1954 and 1964 while corresponding employment declined by 1 percent per year. This is probably an extreme case, but there is evidence from many other underdeveloped countries of output growing rapidly while employment stagnates.

Nigerian planners should take a good look at investment projects in Nigeria to see whether (because of a distorted pricing system) there are not many cases where greater labor-intensity and higher money cost would not actually result in an increase in real income. The place to start is with government projects, which are a third of capital formation. There is not much scope for economizing on industrial machinery, which tends to be employment creating rather than employment destroying. The greatest misuse of machines is to be found in construction and civil engineering, where machines are imported to move dirt and other objects which labor could move just as well. Heavy import duties on bulldozers and similar creators of unemployment would be justified, especially if levied on government as well as private uses.

Agriculture and Services

The labor force is about one third of the population, and about 30 percent of it is non-agricultural jobs. The non-agricultural labor force is therefore about 10 percent of the population. Its growth rate (allowing for productivity increases) can at most attain 5 percent per annum; and its retirement rate is about 4 percent per annum (so high because the average woman spends only a short time in the labor force). Thus the non-agricultural labor force can absorb annually 9 percent of itself, which is 0.9 percent of the population. Since the number of persons entering the labor force annually is about 2 percent of the population, it follows that non-agriculture can take only 45 percent of each new generation; the other 55 percent

must stay on the farms. This is no tragedy, since Nigeria needs that 55 percent in agriculture anyway if the country is to feed itself. Consequently, half of employment policy must consist of persuading 50 to 60 percent of the young people to take up farming; the other half consists of ensuring that non-agricultural jobs expand fast enough to absorb the remainder.

Non-agricultural employment has to be provided mainly by services: these add far more than manufacturing or mining. However, the rate of growth of services is constrained by the rate of growth of commodities (transport, distribution and other commercial services depend on the volume of traffic to be handled, while government services depend on being able to tax the commodity producers). Hence the expansion of services depends on the prime movers of the economy, which can be identified for Nigeria as agricultural exports, manufacturing and oil. The faster these grow the faster services will grow, and therefore the more non-agricultural employment there will be. In particular, the more profitable agriculture becomes, the greater the likelihood that 55 percent of school-leavers will be willing to enter it (on the one hand) and also the greater will be the expansion of services, industries and manufacturing, to absorb the remaining 45 percent (on the other hand). If agriculture does not grow, neither will transport, distribution, government services nor (after the import substitution stage is exhausted) manufacturing.

Fortunately both the market opportunities and the technological opportunities in agriculture are great. The market prospect is good because Nigeria's exports are well balanced, and because her costs are low in comparison with costs in other continents. Her sales can continue to expand by 5 or 6 percent per annum without significant effects on prices. Thanks to research on high-yielding varieties, any Southern farmer could make himself "rich" over the next seven years by replanting his current acreages of cocoa, rubber or oil palm with trees which yield from three to six times what he now gets per acre. With fertilizers, better varieties, and improved cultivation, the Northern farmer could double his yields of groundnuts or cotton. With new varieties and fertilizers one can double the yields of maize or guinea corn or yams. A highly significant contribution to employment, then, could result from successful policies to induce farmers to take up these opportunities.

[Excerpted from Reflections on Nigeria's Economic Growth. Paris: Development Centre, Organization for Economic Cooperation and Development, 1967, pp. 41-47.]

Factors Affecting Industrial Employment

Azarias Baryaruha

[Despite a decade of increases in output fewer people are employed in non-agricultural sectors of Uganda. Reasons for this are sought in five case studies of large industrial firms.]

This study was prompted by the failure of employment to expand in Uganda in recent years. The main part of the study was that of carrying out case studies of some of the major firms in Uganda examining factors affecting industrial employment. The investigations were designed to find out what employers have been doing with regard to their labor, e.g., to what extent has capital been substituted for labor?, has labor productivity been raised by careful selection methods, training, etc. ?, to what extent have changes been due to rising wages or other factors?

Employment, Output and Productivity

Between 1954 and 1964, the total recorded employment in Uganda fell 13.2 percent from 259,220 to 224,894, a decline of 1.4 percent per annum. Employment of Africans during the same period fell by 5.5 percent or 0.6 percent annually. Gross domestic product (GDP), however, increased 60 percent.

The major determinant of GDP is agricultural export values which have no direct effect on employment, being produced in the peasant agricultural sector and priced in world markets. A better approximation to the relevant measures is given when GDP

Mr. Baryaruha is with the Economic Development Research Project, Sociology Research and Economics Department, Makerere University College, Kampala, Uganda.

and employment in agriculture are excluded. In the remaining sectors, the product is produced by paid labor which corresponds with recorded employment in these sectors and the relationship between employment and product should be more meaningful. The change over the period 1954-64 is a 40-percent increase in real product from 13 percent fewer employees. This implies a rise in productivity of 61 percent or an annual rate of increase of 5 percent. This is a very high rate, and it means that output must expand 5 percent each year just to maintain employment. Increases in productivity must be welcomed, but they are a mixed blessing.

In the sectoral breakdown, the construction industry is the only one showing decrease in product, and also a major decrease in employment. In other sectors, product increased while employment declined or, in manufacturing, there was a smaller increase in employment.

Wages. With the exception of cotton ginning and construction, where increases in the wage bill between 1954 and 1964 were 20-30 percent, increases in other industries were all over 200 percent. The most notable increases took place in commerce, Central Government, education and medical services. It is significant that while GDP and employment in construction declined between 1954 and 1964, the wage bill increased.

An analysis of changes in the average cash wage per African employee over the ten-year period 1954-64 reveal fantastic increases of 200-400 percent, with highest increases in mining, Central Government and Local Government, in that order. In Central Government rapid increases in the average wage mainly reflect the effect of Africanization; in this sector, employment increased by nearly 39 percent over the ten-year period.

These big increases in the average wage result from three elements in the changing wage and employment structure: 1) a general increase in wage rates; 2) a closing up of the wage structure from the bottom; and 3) an absolute reduction in the number of unskilled workers employed. Statutory minimum wage rates, varying by locality, were approximately doubled in the larger urban centers.

Data from Case Studies

Six firms were chosen for study, either because they had employment records extending some years back or because their experience was thought to be particularly relevant. However, they do not represent a sample of all employers. Table 1 presents some significant relationships from the case studies. The length of period shown differs for each firm, due to availability of data. However, the

significant data at least for the period 1960-63 are shown in the table; and it is possible to compare the experience of the six firms since all changes have been reduced to an annual basis.

Table 1: Annual Rates of Change in Six Selected Firms
(in percentages)

Firm	Period	Employment	Capital	Output	Wage Bill	Capital Intensity (Capital/ Empl.)	Productivity (Output/ Empl.)	Productivity (Output/ Capital)	Wages (Wage Bill/ Employment)
Nytil (Textiles)	1960-63	12.7	19.1	26.5	29.5	5.7	12.2	6.2	14.9
Uganda Breweries (Beer)	1960/61 to 1963/64	-1.7	1.9	4.8	7.0	3.7	6.6	2.8	8.7
B.A.T. Uganda	1951-55	-6.5	n.a.	5.9	n.a.	n.a.	13.3	n.a.	n.a.
(Tobacco)	1960-64	-6.2	n.a.	-2.9	3.3	n.a.	3.4	n.a.	10.2
Kilembe Mines	1957-60	11.2	5.3	24.8	28.2	-5.6	12.3	18.5	15.3
(Copper)	1960-64	5.1	3.6	5.5	6.5	-1.4	0.4	1.8	1.8
Sikh Saw Mills	1959-63	---	---	---	7.6	---	---	---	8.3
	1960-64	-5.8	3.5	6.2	---	9.9	15.9	2.6	---
Sugar Works - Kakira	1955-60	-1.6	n.a.	8.2	---	n.a.	8.7	n.a.	---
	1959-63	---	n.a.	---	14.4	n.a.	---	n.a.	11.6
	1960-64	0.8	n.a.	6.2	---	n.a.	4.3	n.a.	---

NOTE: Output is measured by quantity--tons, yards of cloth, cases of beer. Data on rates of change in value of sales show closely similar trends in most cases. Capital is measured by the value of fixed assets--when available.

Nytil (Nyanza Textile Industries, Inc.) is certainly not typical, nor is Kilembe, because they both expanded their employment at a fairly high rate. The remaining firms show behavior which fits into the general pattern, with decreasing employment and increasing output for the most part and with sharply rising labor productivity.

Where capital figures are available, the table shows that only Kilembe reduced its capital intensity; but this probably only reflects a gradual working up to capacity of the major items of capital equipment. Sikh Saw Mills increased capital intensity most, which is not surprising because the operations lend themselves to a choice between relatively unskilled labor and machines. The price of the former having been forced up, employment was reduced at 5.8 percent per annum in spite of production increasing at 6.2 percent per annum, giving an increase in labor productivity of 15.9 percent per annum—much the same as that calculated for the economy as a whole excluding agriculture and construction. Nytil is the exceptional case in which production was expanding very fast and both employment and capital increasing, yet here too, the capital/labor ratio rose by 5.7 percent per annum.

In all the firms studied, with the exception of the sugar mill, considerable attention was given to training methods at supervisory and working levels. Where justified by the numbers involved, aptitude tests were used in recruiting, and performance evaluation methods were applied to jobs and individuals. These procedures have undoubtedly contributed to the widespread increases in labor productivity.

In Table 2 an assessment of the relative importance of the several factors leading to increased productivity is attempted. The factors to which the observed increases in each firm might be attributed have been ordered in importance on the basis of the writer's own judgment.

Table 2: Summary of Factors Affecting Productivity Ordered According to Estimated Importance

Case Study Number	Firm	CAPITAL		LABOR					
		Increased Intensity	Increased Efficiency[a/]	Efficient Organization	Better Selection	Greater Stability	Training	Education	Better Nutrition
1	Nytil	1	3	6	5	7	2	8	4
2	Uganda Breweries	1	3	2	4	5	6	8	7
3	B.A.T. Uganda	1	2	6	5	4	3	8	7
4	Kilembe Mines	3	2	5	4	6	1	8	7
5	Sikh Saw Mills	1	3	2	5	4	6	7	8
6	Sugar Works - Kakira	1	2	3	5	6	4	7	8

a/ Including greater use of capacity.

Productivity and Technology

At the risk of stating the obvious it is clear that we are developing at the wrong time. The production techniques in the industries which are being established in developing countries are biased in favor of capital (the scarce factor) and against labor (the abundant factor). This is due partly to the dictates of international technological advancement and partly to the fact that, in countries where capital and capital equipment are obtainable, the equipment is designed on the assumption that labor is the scarce factor. Further, since it is becoming fashionable to give "tied aid," this narrows still further the choice open to developing countries as to the techniques they employ. Moreover, the large investing firms in developing countries are generally branches of big established companies in developed countries with the result that the branches stick more to the latest production techniques in use at "home" because this is

what they are used to, and pay little attention to the requirements of national factor proportions. It is suggested that Nytil and B. A. T. might have found a more labor-intensive technique to give the same profit had the necessary research been carried out; and even if this were not possible it is arguable that they should have been induced to accept a suboptimal technique for social reasons.

Closely related to this question of choice of technique is the question as to what extent the failure of employment to expand can be attributed to rapid increases in wages. While there is no evidence that rapid increases in wages prevented potential firms from being established, evidence that already established firms have used labor very sparingly does exist. Increases in wage rates do, in some cases, motivate firms towards changing the technology they have been using in a more capital-intensive direction. Because of the minimum wage laws and other "high-wage" pressures, firms have resorted, not only to substitution of capital for labor, but to measures like training workers and supervisors, and more efficient use of capital and labor; measures which have resulted in a reduction of employment because the productivity of the few has been raised.

Investment in skills may be a good thing but rapid mechanization resulting in many people staying idle is another matter. If, however, one accepts the argument that experience over the years would have led the firms to check whether labor was being used efficiently or not, then minimum wage legislation has only accelerated the pace at which people have been pushed out of employment. To the extent that these people would not have been in employment in the first place but for very low wages causing labor to be treated like a free good, the "slack" has now been taken up. The experience of the last decade may have been unique and the prospect brighter than this period suggests.

Nevertheless, it cannot be stated in too strong terms that employment creation remains a big challenge to any government or economic planner. The widening gap in income and social amenities between urban and rural areas continues to attract the underemployed reserve in rural areas to seek to improve their lot by looking for new opportunities in the modern sector, and also the young primary school-leavers whose aspirations for white collar jobs are very high.

[Excerpted from Factors Affecting Industrial Employment: A Study of Ugandan Experience 1954 to 1964. Nairobi: Oxford University Press for the East African Institute of Social Research, Makerere University College, Kampala, Uganda, 1967, EAISR Occasional Paper No. 1, pp. 1-16 and 76-80.

Manpower Mobilization for Development

Andres D. Goseco

[Taiwan's successful use of labor-intensive projects to mobilize unemployed ex-servicemen in building capital assets deserves study in other countries.]

Any discussion of Taiwan's successful economic development would be incomplete without a note on the effective employment of one factor of production that it has in abundance—manpower. An already high population density was aggravated by the influx of a sizable migration from Mainland China in the early 1950s. Where capital is short and land scarce, and where the only abundant resource is manpower, could better recourse to manpower have been made than to utilize it in labor-intensive capital-building work? And what more satisfactory choice could there be than retired servicemen who, besides being in need of employment are also motivated, skilled, disciplined, mobile, hardy and cheap to employ? This then is the logic in Taiwan's massive employment of retired servicemen. (It is interesting to note that Mainland China has a similar program. There, too, retired servicemen have been employed in massive capital-building work, such as land development, with the land so reclaimed being subsequently settled by the servicemen.)

The Vocational Assistance Commission for Retired Servicemen (VACRS) was established in 1954. As of December 1966, VACRS had assisted 155,709 servicemen in finding employment in the community or in the

Mr. Goseco is a Programme Analyst in the Programme Formulation and Budget Division, Food and Agriculture Organization of the United Nations (FAO), Rome.

many business enterprises assisted and operated by VACRS, in the fields of agriculture, forestry, fisheries, commerce and industry. Among its many projects are the 404-kilometer East/West Highway across Taiwan, harbor and airfield construction, and land development. By the end of 1965, some 7,800 hectares of wasteland had been reclaimed, and some 16,400 hectares of land have been found suitable for reclamation.

The Project

The project described here is concerned with the reclamation of 2,530 hectares of riparian and mountain lands where 3,450 retired servicemen have been settled.

The land. The riparian land, accounting for 94 percent of the total reclaimed in this project, is of a type found in Taiwan river deltas. It spreads out funnel-shaped toward the sea, and is generally flat, heavily strewn with rocks and stones, with an underlay of sand and gravel, and is absolute wasteland. During periods of heavy rainfall, such land becomes one vast torrent which often overflows and damages the adjacent farmlands; its nature is so difficult that few specialists were convinced that it could be kept under cultivation when the idea was first put forward in the early 1950s. Mountain lands (the other 6 percent) had been inaccessible but are otherwise arable lands capable of supporting a wide range of crops.

The settlers consist mainly of unmarried, retired servicemen, in their forties, physically fit and able to perform a good day's work on the farms. They have undergone selection prior to settlement. They are accustomed to taking orders, are hard working and highly mobile. They do not seem to mind the discipline of their life, nor do they apparently object to living together, sharing the production, and eating from a communal kitchen. Living conditions are simple but adequate; sanitation standards are generally good; bicycles and radios abound on the settlement sites. Since most of the settlement projects are located adjacent to established communities, it is possible for the settlers to enjoy a modicum of social life.

The preparatory work consisted of surveying, building of dikes, roads and bridges, construction of the irrigation and drainage system and houses; land filling, leveling and terracing. It is labor-intensive in the extreme, requiring a minimum of machinery and construction materials that need to be purchased. The dikes, roads and farm structures were built by carring stones from the riverbeds by hand. Large boulders were dynamited to facilitate moving and collection. The land was similarly worked to obtain the desired contour and the soil was built up by removing the stones, gravel and coarse sand and mixing the remaining sand with soil brought in from

outside the area. Another way of building the soil is to allow the silt-laden river water to settle and leave its silt on the land; this, however, can be done only on rainy days. It takes a few days of repeated silting to build the soil up to the desired texture and thickness, after which the land is ready for cultivation. Experience shows that it requires some 1,200 man-days per hectare to develop such lands. A minimum overlay of 15 to 20 centimeters of soil is needed to produce crops. The resulting soil is of poor quality, but fertility can be built into it, as was done in fact over a period of time by the application of fertilizers and organic matter. Croplands adjacent to the project areas were similarly reclaimed some years back and are as productive as any land in Taiwan.

It took an average of three years to prepare the land for settlement—more for the riparian lands where a complex system of dikes and irrigation works had to be built, and less for the mountain lands. The first two years were spent in constructing the infrastructure; the third in building the soil and preparing it for cultivation. Crop production began only during the fourth year.

Organization. The system under which VACRS organized the cooperative farms for reclamation and settlement has the following features:

1. Several production groups, with 20-24 men each, working with 11-13 hectares, make up a cooperative farm.

2. The cooperative is charged with planning the overall production program for each group's allotted land. This function is still nominally performed by the local VACRS office staff of 15-30 people.

3. Except for the crops covered by marketing agreements, each production group may dispose of produce at its own wish and risk. The cooperative farm may provide the marketing venue and facilities.

4. Each production group may decide for itself the type of sideline production that it wishes to undertake (livestock, vegetables, etc.).

5. Each production group maintains its own accounts and shares its income equally among its members.

Self-management is prescribed, and the production groups are organized on the principle that "each group supports itself at its own risk." A form of tenurial right is conferred to the production group on the land it reclaimed and presently cultivates.

Within each production group, work is allocated by the leader, whom the members elect periodically from among themselves. Business decisions are arrived at by internal consultation. The individual member may withdraw from the group upon marriage or when he retires because of old age. In case of marriage, he is given his own piece of land, varying in size from 1.5 to 3 hectares depending on the number of his dependents.

The arrangement is, from all appearances, a workable one; the settlers work hard and for long hours, contrary to the common experience that sharing production equally is not conducive to hard work. It is not easy to explain this phenomenon and, in the absence of a deeper sociological study, one can only guess at possibilities (see below).

Economic Contribution and Cost of the Project

The original investment for the project amounts to U.S. $1,775,700, or an average reclamation cost of $702 per hectare. This compares favorably with the cost of reclaiming and equipping land elsewhere. For instance, the cost in the United Arab Republic averages $1,280, while that of reclaiming tidal lands costs some $5,600 in the Netherlands and $3,000 in the Republic of Korea.

The crops produced are pineapples, sweet potatoes, soybeans, sugarcane, cocoa beans and vegetables. A basic complement of 20 pigs, 2 head of cattle or water buffalo, and 100 chickens is given to each production group at the start of settlement. Production during the first crop year on the 2,530 hectares of land reclaimed had a total value of $925,000. Initial yields approached, and in some cases surpassed, Taiwan averages, but substantially higher output, estimated at $1,743,000, is expected on the basis of experience with similarly reclaimed lands adjacent to the cooperative farms. Full production is generally attained in the fifth or sixth year (after three or four crops) provided the soil is continually built up and fertilized in the interim.

With regard to the amortization and interest of the investments and capital expenditures, a shadow interest rate of 8 percent per year was adopted. This is somewhat lower than the market rate in Taiwan for long-term money, which averaged about 11 percent annually during the last five years, but higher than the subsidized rate to agriculture of 6-7 percent. (A somewhat lower interest rate was assigned to World Food Program contributions—6 percent, since this resource was obtained internationally.) An allowance of 5 percent of the cost of the structures should be sufficient to cover maintenance and operations, and 2 percent would be adequate to cover

any major repair operations that may take place. Total cost of amortization and maintenance is $220,000 a year.

In estimating the cost of producing the crops shadow costs were used, based largely on recent farm management studies reconciled against the actual production cost experienced in the cooperative farms in question. Direct costs of $1,258,000 per year deducted from the estimated product implies annual net benefits of $485,000. This gives a benefit/cost ratio of 2.2:1 for the investment. The project yielded an internal rate of return of 18 percent. This is a satisfactory position, since a benefit/cost ratio of 1:1 and a rate of return of 11 percent are acceptable levels under conditions in Taiwan.

Employment Impact

It is evident from the data that this is indeed a labor-intensive undertaking, since some 89 percent of the inputs was contributed by labor or in direct support to it. A somewhat different method of measuring the economic merit of the project is possible in the context of a labor-surplus economy; there is presumably little or no alternative employment for the labor used on the project. Since the laborers would have been fed, clothed and sheltered anyhow, employed or not, the real cost to the economy of employing them can be represented as the extra consumption that has arisen from their being so employed (in hard work, etc.), as opposed to what might have been their consumption in a state of unemployment. If we assume the extra consumption is 20 percent of the cost of the labor input, the benefit/cost ratio would then be 3.8:1.

The purpose of this exercise is to demonstrate that it is really not so costly as many believe to employ raw manpower in capital building and labor-intensive works in a labor-surplus economy. This argument would apply with even more force if we consider that, had the laborers been allowed to remain in a state of unemployment, they not only would have been a drag on the economy but also might have contributed to social tension and thus added to the cost of keeping the peace.

Finally, the exercise serves to emphasize the point that there can indeed be a highly utilizable but idle "capital" pool in the presence of a large unemployed labor force in a developing economy. This is a point often missed if it is assumed that capital and labor are two separate but inextricably interdependent factors, that one must necessarily attend the other and, since capital is almost always in short supply, a large proportion of the labor force cannot as a result be actively employed. It has been demonstrated here that much development work can be done with labor and little else. Here is the logic of the massive and intensive employment of labor—the so-called

"Chinese" method—in capital building and labor-intensive work. It may indeed be said that it is by so employing its labor force that Taiwan has been able to practically eliminate unemployment.

Possible Relevance to Other Developing Countries

It is not easy to draw particular lessons from this project because of the heavy "Chinese" content of the experience. There is, in the first instance, the Chinese tradition of group action. It may be that the social sanctions exercised by the group on the individual have been a major factor, the influence tending to be more effective where the group is of a small size and of greater compatibility. There might have been less positive response had the production groups been much larger. It is also possible to explain the phenomenon in terms of the strong motivation of the settlers and their military conditioning to group action.

Aside from the unique system of cooperatives employed, the other organizational methods and institutions used are working procedures, services and coordination techniques applied in similar programs in other countries. Here one may point to the mixed experience—success side by side with failure—attending such programs in other countries, despite their common utilization of the same institutions. What might appear to be the keys to success in this project are the workers' diligence, discipline, and effective organization. Similar programs pursued in different ideological settings but attended by the same diligence on the part of the workers have also been known to succeed—and also to fail when pursued less vigorously. One is led to the conclusion that ideologies and institutions are not the key items. Other countries should experiment with the approach, not only to gain the necessary experience and learn the appropriate adaptations, but also to build up the required reservoir of diligence and discipline on the part of the people.

[Excerpted from "Manpower Mobilization for Economic Development: A Case Study of its Application to Land Reclamation and Settlement in China (Taiwan)," Monthly Bulletin of Agricultural Economics and Statistics. Rome: FAO, Vol. 17, No. 3, March 1968, pp. 1-12.]

Works Program in East Pakistan

John Woodward Thomas

[Extensive use of farm labor during slack seasons for road building, flood control and drainage works in rural East Pakistan has brought economic benefits to a poor and stagnating economy. Employment and wage results are notable.]

As part of a new strategy of economic development, the Government of Pakistan, in October, 1961, signed an agreement with the United States Government for the supply, over a four-year period, of $621 million of agricultural surplus commodities under U. S. Public Law 480. This program was designed, in large part, to finance a Rural Public Works Program intended to convert idle labor into capital, to raise the level of nutrition of the landless and unemployed, to provide basic rural facilities which would promote growth of agricultural production, and to stimulate the economy by providing new demand for domestically produced goods.

Since the Program was initiated on a pilot basis, it has grown into a provincewide activity in which the Government of East Pakistan has invested $149 million; since 1963, expenditures on the Program have averaged about 8 percent of the annual development program. It has been carried out under a decentralized system, in which annual allotments of funds are made to the local councils of the province under the "Basic Democracies" system. The councils bear responsibility for planning and implementing projects in their areas. This highly decentralized system of administration, utilizing local administrative

Mr. Thomas is an Advisor with the
Harvard Development Advisory
Service Project, Dacca, East Pakistan.

capabilities, avoids the use of scarce administrative resources and represents an innovation in the conduct of development programs.

The Rural Economy of East Pakistan

Most of East Pakistan's 55,000 square miles comprise the deltic plain of the Ganges and Brahmaputra Rivers; rivers constitute $5\frac{1}{2}$ percent of this area. In 1960, the population of the province was 53.9 million, of which 94.6 percent lived in rural areas. The population density averaged 1,037 persons per square mile, more than double the densities of the Netherlands, Japan and Taiwan, or of Kerala in India.

As recently as the 1920s the area had produced a large rice surplus, but from 1930 to 1960 the population had jumped from 35 to 54 million and the rice surplus had been replaced by a deficit that required the import of 580,000 tons of foodgrains in 1960. While rice production remained constant in the decade of the 1950s, the population grew by 23.2 percent and per capita income declined from 293 to 263 rupees [4.8 rupees = $1]. Such development as had taken place since the formation of Pakistan had been in the industrial sector, most notably in jute processing, and the benefits had been concentrated in urban areas.

From 1947 to 1960, East Pakistan's farmers, undernourished, with gradually declining incomes, with little local leadership and no funds, struggled simply to maintain themselves and their families. As population grew, land was divided and subdivided until the cultivated area per farm dwindled to an average of 3.1 acres; 80 percent of the 6.5 million farm holdings were less than 3 acres, and 1.5 million rural inhabitants were classified as landless laborers without the opportunity to be tenant farmers.

The Pilot Works Program at Comilla, 1961-62

Following a period of planning and debate, the second stage in the evolution of the Works Program began in May, 1961, when the Director of the East Pakistan Academy for Rural Development agreed to undertake a pilot works program. A year later the pilot project could boast an impressive list of accomplishments: flood control embankments were constructed, canals cleared, and roads built. It had employed an appreciable segment of the idle labor force in the area, and increased their purchasing power. It had increased the rice crop by limiting flood damage. It had enabled farmers to get their crops to market on the newly built roads. It had increased the confidence of the residents of the area in their own capacity to function effectively for their own improvement.

The value of the testing process in the pilot project can be seen in two examples. First, it had been anticipated that the local councils would contribute a fixed percentage of the cost of each project. This system was abandoned after it was found to be counter-productive because it led to substantial corruption and to a diminution of the benefit to those the program was designed to assist. Cost estimates were inflated; laborers were underpaid or forced to contribute part of their time without pay; measurements of earth moved were inflated; and many little devices were found to falsify the public contribution. In fact, it was discovered that there was almost no public contribution, and those who lost the most because of the so-called public contribution were the laborers, whose need was greatest.

Second, in order to encourage wheat consumption, it was decided to pay laborers a portion of their wages in wheat. When laborers were paid with wheat valued on a par with rice at Rs 20 per maund [one maund = 82.2 pounds], they found it unacceptable. When, however, the ratio of the price of wheat to the price of rice was altered and wheat was valued at Rs 12 per maund, it was acceptable payment. The government learned from this experience that to ensure wheat consumption by the rice-eating East Pakistanis, which was central to the operation of the P. L. 480 program, wheat sales would have to be subsidized.

Accomplishments of the Works Program

From 1962/63 to 1966/67, an average of Rs 142 million has been spent annually through the Works Program. There is clear evidence that the Works Program is in fact succeeding in developing a rural infrastructure. Road mileage in the province has been increased more than 10 times. Drainage projects have been effected on almost all the waterlogged land which has agricultural potential and which can be drained by gravity flow. Embankments have been built where flood waters can be controlled by works of a size which the Works Program can construct.

On the basis of an intensive, independent investigation of eight sample areas, it would appear that the Works Program projects have, on the whole, been planned with due consideration of the economic needs of the areas and that their location has usually coincided with economic priorities for development. The evidence also indicates that all drainage canals have been maintained, and that over 95 percent of the road mileage has been maintained. Roughly 25 percent of the embankments, however, have deteriorated so that they have less than their initial water resistance capacity. It should also be noted that approximately 10 percent of the bridges have been inadequate for the carrying capacity for which they were designed. But

the maintenance of Works Program roads and embankments has been markedly better than that of similar facilities built on a small scale in the rural areas by provincial agencies.

An overall assessment of the economic benefits from the Works Program projects completed by 1967 is shown in the table below. If this annual flow of benefits is assumed to have a 15-year life, and the total value for such a period is compared with the cost of the projects' construction, then a highly favorable benefit/cost ratio of 4.0 is obtained. This indicates that the investment in such public works is amply justified in economic terms, aside from other benefits that may be claimed for the Program.

Table 1: Calculation of Net Annual Benefits from Works Program Projects Completed by 1967 (in million Rupees)

Benefits:		
1. Road user savings (for carrying agricultural produce only)	157.5	
Less production loss, land used for roads—44, 155 tons	- 26.8	130.7
2. Increased production from land drained		221.2
3. Flood protection: 1.7 million acres		100.4
		452.3
Less Maintenance		
Roads @ Rs 560 per mile	56.6	
Drainage, re-excavation every 5 years	4.4	
Embankments 7, 168 miles maintained @ Rs 560 per mile	3.8	
		- 64.8
Net Annual Benefits from R. W. P. Projects		Rs 387.5

The Contribution of Works Program Roads

Approximately 75 percent of Works Program funds have been used for the construction of roads. In 1963 there was reportedly a total of 3, 411 miles of good quality road, both dirt and paved, in East Pakistan. The 101, 000 miles of roads built and repaired in

rural East Pakistan from 1963 on (even after allowing for the roads repaired more than once) represent a major jump in the mileage of usable roads; only the Thana Council roads (35; 000 miles), however, are comparable to the pre-Works Program mileage reported for 1963. Such roads are usually dirt-surfaced roads that can accommodate most conveyances except heavy trucks; the remainder, built by Union Councils, are smaller and are frequently limited in capacity to foot, bicycle, rickshaw, and light animal-cart traffic.

One major consequence of the construction of roads has been an increase in the facilities for carrying agricultural produce to market. Table 2 below shows the increase in numbers of commercial vehicles in the areas surveyed. Another consequence has been that rural transportation costs declined by a roughly estimated 35 percent between 1962 and 1967, even though prices generally, and urban transportation costs specifically, rose during that period.

Table 2: Change in Number of Commercial Vehicles in Eight Areas of East Pakistan 1962-67

	Rickshaws	Animal-Carts	Trucks	Scooter-Taxis	Bicycles	Buses
1962	110	3, 159	10	0	1, 200	15
1967	491	4, 607	65	40	2, 250	90

For decades the East Pakistan farmer has grown rice mainly for his own consumption. To meet the need for household items which he cannot produce, he has traditionally planted a small field of jute, which yields a few pounds of fiber. This he bartered to the itinerant trader in exchange for basic household necessities. The traders usually agree to work in certain areas and do not operate within one another's jurisdiction; they can thus offer farmers the lowest possible prices. With no means of traveling to local markets, farmers with only small quantities for sale have been virtually helpless. A 1967 survey sought to find out from farmers whether they were then producing or selling crops which they had not produced or sold in the early 1960s prior to the existence of Works Program roads, and if they had changed the manner in which they sold goods. A total of 123 farmers in eight areas were asked these questions, and the responses, summarized in Table 3, show an increase in sales of rice, a major increase in the number of farmers selling in the markets rather than to traders, and a shift in cropping patterns to more cash crops.

Table 3: Change in Production and Marketing Patterns of Selected Crops in East Pakistan, 1962-67

	A	B		C	
	Number growing commodity	Number growing for sale	B/A	Number of those selling who well primarily in the market	C/B
Total sample: 123					
Rice					
1962	123	45	(36%)	16	(36%)
1967	123	70	(57%)	57	(82%)
Jute					
1962	81	81		27	(33%)
1967	81	81		56	(69%)
Vegetables					
1962	n.a.	13		5	(38%)
1967	n.a.	50		48	(96%)
Sugarcane					
1962	n.a.	8		5	(62%)
1967	n.a.	21		16	(76%)
Minor crops					
1962	n.a.	15		4	(26%)
1967	n.a.	36		30	(83%)

Employment Effects

One of the principal purposes of the Works Program was that of creating employment. The agricultural labor force (77 percent of the total labor force) in 1961 was estimated at 14.9 million persons; voluntary and involuntary unemployment was estimated at 33 percent of total available man-days.

Government figures for employment in the Works Program (as modified by the survey noted above) totaled over 200 million man-days from 1962/63 to 1966/67. If these estimates are converted into man-years, on the basis of 240 working days per year, the Works Program has created 866,000 man-years of employment in a five-year period, or 173,200 man-years annually. Although this seems an impressive figure, employment on this scale would mean a mere 3.4 percent decrease in annual agricultural unemployment in East Pakistan.

These figures, however, understate the Program's real impact because rural unemployment in East Pakistan is primarily a seasonal phenomenon. During the planting and harvesting seasons, which occur four times a year, it is rare to find anyone physically able and desiring work who is without employment. Between these seasons unemployment rises, particularly among the landless agricultural laborers who have no full-time employment, probably to a figure between 30 percent and 40 percent. After the fall harvest comes a slack season, January to May. During this interval, when there is no rain and when the temperature reaches its annual peak, there is almost no agricultural activity and unemployment probably reaches 60 to 70 percent of the agricultural labor force. Wages earned at other times of the year are often insufficient to sustain workers through this period unless they can find employment for part of this time. It is in this January-May peak period of unemployment that the activities of the Works Program have been concentrated. Because this employment is concentrated within this short period, many more workers are employed than the figure of 173,200 annual man-years of employment would indicate; an estimated 600,000 to one million men were employed each year for periods varying from two weeks to four months. If indirect employment benefits could also be calculated, the impact would be even greater.

The Works Program is only a partial solution to the unemployment problem, but it does provide a substantial increase in income for many farm laborers and it has, therefore, relieved some of the most serious social inequities and pressures resulting from the unemployment situation. In the late 1950s and early 1960s, the employers of unskilled labor in the slack season, primarily construction contractors and brickmakers, employed only a small number of laborers and paid an average wage of Rs 0.75 (U.S. $0.15) per day. This is a subsistence wage in East Pakistan, barely sufficient to cover the cost of the worker's food. At the inception of the Works Program in 1962/63, wages for unskilled labor on the Works Program were established throughout East Pakistan at Rs 1.50 to Rs 2.00 per day.

By 1967 slack season wage rates had increased in both Works Program and other employment. In the Works Program the average daily wage for unskilled labor was Rs 2.00 to Rs 2.50, while outside wages were between Rs 1.75 and Rs 2.25. Non-Works Program employers indicated that the increase was necessary to compete in the labor market with the Works Program; they have no difficulty in obtaining labor at wage rates slightly below those of the Works Program. The Works Program had not absorbed a majority of the unemployed, for there is still considerable unemployment in the slack season. Industrial wages did not rise by much during the period, so that the increase in rural wages was not part of a general upward

trend in wages but a result of conditions in the rural areas. The best explanation of the increases in rural wage rates is that there are a limited number of laborers prepared to work at near subsistence wages and that the Works Program has engaged most of these.

In the slack season there are varying degrees of need among the unemployed, who can be divided into three groups. First, there are unskilled laborers who own no land and have no regular occupation; some in this group are sufficiently desperate to accept employment at subsistence wages, and the remainder will work for very low wages. Second, among slack-season unemployed are those who have small plots of land, usually less than one acre, or who have some irregular employment. This group will work if wages are reasonable but will not work at subsistence wages. The third group are farmers with one or more acres of land, or those who have regular employment but have been temporarily laid off. This group, though unemployed at the time, will not usually accept hard, unskilled labor unless wages are extraordinarily high.

The wage data suggest that most of those in the first group have obtained work in the Works Program. Many in the second group, which is larger, also work on the Works Program projects, but not all in this group who seek jobs are thus employed. As a result, the non-Works Program employers can no longer find laborers to work at subsistence wages, and have been forced to pay what are approximately "going" rates in order to attract a sufficient number of workers from the second group to meet their labor requirements. If this explanation is valid, the Works Program has performed an important service in eliminating the use of subsistence wage rates, and in providing regular work at more reasonable rates during the three to four months slack season for the lowest economic group which previously worked, if at all, for a daily wage of Rs .75. If there are 70 working days in the slack season, and a laborer can now earn Rs 2.00 rather than Rs .75, his income for the period has increased by Rs 87.50, an important addition for members of a group in which per capita incomes are approximately Rs 200 per year.

[Excerpted from "Rural Public Works and East Pakistan's Development." Cambridge (Mass.): Development Advisory Service, Harvard University, Economic Development Report No. 112, 1968, pp. 2-78. To be published in Development Policy II - The Pakistan Experience, Walter P. Falcon and Gustav F. Papanek (eds.), Harvard University Press.]

Job Training for Youth

International Labor Office (ILO),
Geneva

[ILO has been giving increased attention to the problems of vocational preparation, guidance and employment of young people in the developing countries. Together with the United Nations Children's Fund (UNICEF) it is assisting prevocational training programs for early school-leavers in African, Asian and Latin American countries. A few of the ILO-supported programs are described.]

In most of the developing countries there has been significant progress towards the goal of compulsory primary education. But primary education has tended to be too town-oriented and too much patterned on the traditions of the older industrialized countries. There is a need to relate rural schools to the rural environment and to give agriculture and rural crafts their proper place.

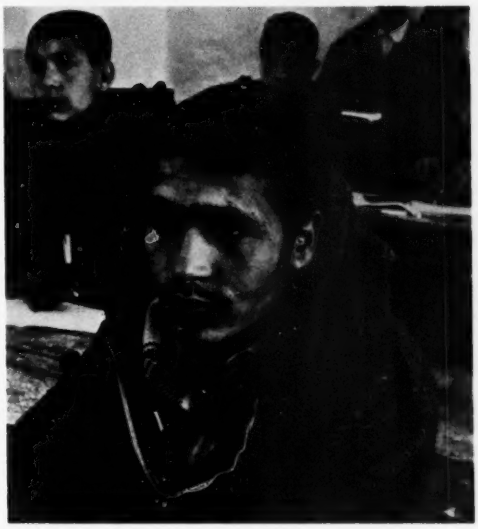
At the middle or secondary levels of education, the problems are also serious. The system of education is based on classical patterns and bears too little relation to national needs and environmental conditions. School-leavers find themselves ill-equipped to make the transition to work life and are often in need of reorientation and training.

There is a recognized need to rethink curricula and teaching methods in relation to national needs and aspirations, and to conceive and regard education not as a status symbol but as a means of human and national development. There is also a great shortage of vocational training opportunities for youth in the developing world and a great need for revision of policies and methods and for relating training more closely to manpower needs for development purposes. There is an urgent need to introduce special and

unorthodox arrangements to help the young get some foundation for their future participation in economic life.

Tunisia: Agricultural Training

Ahmed's future looks a lot brighter now than it did not long ago. Ahmed is 16, the son of a farmer. Discouraged by a hard life and bleak prospects on the land, he probably would have tried his luck in the city—and, like many other youths, ended up a total loss to himself and his society.



But now Ahmed, pictured here, will probably stay on the land after all and build a better life for himself. He is learning the basic skills of modern agriculture, and at the same time filling in the gaps in his general education. After 10 months' training in Tunisia's pioneering rural prevocational training program he will return to his father's farm, equipped with the knowledge to make the land more productive for his family and his country. Thanks to the growing network of rural prevocational training centers, the story of Ahmed will be repeated thousands of times over as the program expands in Tunisia and spreads to other developing nations. Similar programs are already starting up in Cambodia and Thailand.

Agriculture—top priority. To get more out of the land, you have to bring more to it than seed or fertilizer; you must invest in training modern-minded farmers. To reach its agricultural production targets, Tunisia will need some 72,000 skilled agricultural workers to be trained by 1985. Many Tunisian farmers are former nomads who have been settled on virgin lands, which they still must learn to cultivate properly. They must learn to till the soil more deeply, and to select proper seeds. They must learn to irrigate, and to judge the quality of the water. Even former shepherds do not know the best ways to raise cattle.

A vicious circle of rural underdevelopment persists. Youths turn away from agriculture because it is backward and does not offer prospects for a better life, and agriculture stays backward because it is deprived of the skilled young people needed to modernize it. If

this circle is to be broken, youths must somehow be given an appreciation of the rewards that modern agriculture can offer, and the training that it demands.

Filling the gap. Before the prevocational centers were started the government had been building up a network of advanced, four-year agricultural schools and two-year agricultural vocational schools. But many rural youths cannot pass the entrance examinations, and the high cost of training a student in the two-year vocational schools puts a limit on their expansion. The prevocational centers help fill this gap. They offer a practical one-year course for youths of 14-18 years who have completed at least five years of primary education and who for one reason or another cannot continue their academic studies.

The scheme started in 1964 and has grown rapidly. Twenty centers are now operating, and ten more are to open their doors in 1969. More than a thousand young people have been trained already, and the rate will be stepped up as more centers come into existence. Five centers are planned for girls and one is in operation.

Learning by doing. Although all trainees have had at leave five years of primary school, their education background is often uneven. To fill in the gaps, they spend about one quarter of their time studying general subjects—Arabic and French, arithmetic, science, geography and physics. They also learn handicrafts, such as wood and metal working, simple building—the sort of skills that are useful or necessary to a farmer, or that might set a boy on the road to becoming a rural craftsman. But the bulk of the training—about 60 percent of it—is in agricultural subjects. The trainees get a grounding in general principles, but most of the work is practical, and revolves around raising crops on the center's own plot or on adjacent land. Equipment is deliberately kept simple; it's the kind the trainees will find on the farm. And as far as possible the pattern of work follows that of a real farm. This is true also of the center for girls, but there home economics takes the place of handicrafts.

The most important change in the program has been to adapt it to regional needs. At the start it was envisaged as a general introduction to agriculture, and the planners laid out a uniform syllabus. But it became clear that agricultural conditions and activities vary widely from one region to another, so the whole program has been tailored to the conditions and development needs of various regions whose primary activities range from cultivating flowers to raising cattle. The administrative structure has been decentralized: regional agricultural training committees have been formed and now play an important role in creating and launching new centers, and they have taken over responsibility for recruiting and placing trainees.

Tangible results of such a program are hard to measure at this stage. Most of the students, such as these returning their equipment to the shed, are living on cooperative or private farms where traditional techniques are still being employed. After 10 months' training, the trainees obviously do not emerge from the centers ready to run a farm. They may not yet have the authority to put their new knowledge to immediate use, but one day many of them will. Through the young people, the centers also register some impact on their parents.

Colombia: The National Apprenticeship Service (SENA)

At 19 Luis Antonio, pictured below on his way to night school, still has to help his father eight hours a day to earn enough money for the family of six. They still live in the same shack, but now Luis Antonio has succeeded in completing, at night, five years of primary school—the minimum requirement to enroll next year at SENA.

Like similar vocational training schemes in other Latin American countries, SENA is designed to bridge the gap between primary school and work, to give young school-leavers the skills they need to get jobs in industry. These programs supplement the technical schools (which train technicians rather than workers) and admit only older students with higher qualifications.

Under all of these schemes, candidates are admitted only if they have completed primary school or the equivalent, and possess a satisfactory level of skill in reading, writing, and arithmetic. But this requirement does not ensure that there will be no gaps in a candidate's educational attainments. SENA puts candidates through three

to six-months equalizing courses before they actually begin apprenticeship. The courses give them general education, basic workshop training, and vocational orientation, with a view to reducing the number of apprentice drop-outs.

SENA's apprenticeship program covers commercial, service and agricultural occupations as well as industrial jobs, but by far the heaviest enrollment has been in the industrial trades. As a result, SENA, like the vocational schemes in the other countries, is an increasingly important element in the total industrialization process.

In Colombia, SENA operates 38 centers. Since its inception in 1958, SENA has trained more than 250,000 youths in more than 60 different trades. Under its three-year training programs, six-month periods at the centers are sandwiched with six-month periods on the job.

Doorway to a future. An important feature of the programs is that the apprentices continue to earn something during their training. Since most of them come from the poorest section of the population, this is often a determining factor in their ability to enter the program. The wages are not princely, but they are at least as high as the earnings the apprentices are able to achieve outside.

Admission to an apprenticeship does not in itself constitute a guarantee of future employment. Employers are not obliged to keep on their apprentices once they have finished their program. But the prospects are good: some 80 percent of SENA's graduates do in fact continue at the plants in which they have done their on-the-job training.

India: A Second Chance for Drop-Outs

At Shahdera, a suburb of New Delhi, there is a school with unusual entrance requirements. To gain admittance, a boy must be a truant, a drop-out from a primary or secondary school in the area. In India, for every 100 children entering first-year classes, it is estimated that only 29 reach the fifth. But the school, one of more than 60 pilot units set up by the Indian Government with the help of the ILO and other United Nations agencies, is far from being a paradise for rowdies. On the contrary, the staff say discipline is not a problem, and the boys, aged 11 to 14, are being successfully reintegrated into the educational and employment systems.

The pupils enrolled at the center—currently about 100—spend three hours a day learning to handle basic tools. They hammer, cut, sharpen, polish, file and chisel in classrooms such as that shown

at the right. Along with the experience of discovering aptitudes they did not know they possessed and working harmoniously with other boys, the young pupils get training during the three-year course in seven basic trades, some of them—die-casting and mould-making, for instance—requiring fairly advanced skills. The syllabus includes carpentry, forging, fitting, welding and sheet metal work.

Combined with this practical work, the academic studies at Shahdera give a boy a heavy schedule. When he is not hard at it in the workshop, he is studying Hindi, English, mathematics, social studies, general science and community planning. He also finds time for physical training and cultural activities. The latter, scheduled once a week, include Indian songs and dances, and dramatics.

Mr. Kapoor, the school principal, finds the boys bright and aggressive. His observations, which are borne out by ILO studies in a number of countries, suggest that drop-outs in developing areas are not the less intelligent children, as is generally the case in other parts of the world.

Two hundred more centers of the Shahdera type are scheduled to open in urban, semi-urban and rural areas during India's Fourth Five-Year Plan (1969-74). The experience gained at Shahdera and the other pilot projects has been invaluable in planning the new centers. It has been decided, for example, to reduce the emphasis on industrial content for courses in rural areas, and to channel the training in directions more suited to local conditions. Shahdera's own syllabus, like the others, is still in the formative stage; adjustments will no doubt be made to suit industry in the New Delhi area.

[Excerpted from ILO Panorama. Geneva: ILO, No. 35, March-April 1969, pp. 6-21 and 29-32. Photos: ILO.]

Modernization or Obsolescence of the Indian Farmer

Kusum Nair

[The Green Revolution could lead to a displacement of millions of farmers in India with no equivalent openings in urban employment, unless policies to bring about modernization of small farms are followed. Interviews with farmers in India, the U. S. and Japan bring out important differences; for India, the Japanese example is especially instructive]

Initial response to the high-yielding varieties of seeds was spectacular throughout India. In 1967/68 a record crop of 95. 6 million tons of all food grains was harvested. Farmers, traders, and the government ran out of storage space, and the grains lay in heaps out in the open. The High-Yielding Varieties Program and the strategy underlying it were an obvious success.

If current trends are projected, the increase in production could be expected to outstrip the birth rate and convert the food grains deficit of recent decades into a constant surplus. At the same time the modernization process could be expected to create another, more massive surplus—of small peasants. Their output would no longer be critical to aggregate production. The yield potential of the new grain varieties is so high that only the top tenth of the cultivators would need to cultivate them. Rapid enough growth could take place without the rest. They would become irrelevant. In any case, their lands would be bought up by the more aggressive and competent commercial farmers (and non-

Mrs. Nair, an Indian journalist and scholar, is currently with the Asian Studies Center, Michigan State University, East Lansing.

farmers) who would have a strong incentive, and the means, to increase the size of their holdings and operation.

Long before the surplus in food grains came in sight, it was apparent that the small farmer was in trouble under a financial squeeze. The cost of all factors including land was rising, and he was not participating in the production improvement significantly. What is more, the trend was being widely accepted by economists as natural and inevitable; the small farmer was not expected to stay in agriculture.

Impact of Producer Concentration

Even prior to the varietal revolution, around 95 percent of the farm households in India owned less than 20 acres of land each; 75 percent possessed less than 5 acres. Less than 13 percent had more than 10 acres each. Only 1 percent held 50 acres and more.

If only the less-than-five-acre farms are eliminated in the "modernization" process, some 33 million families—aside from the 15 million or so that do not own any land—would be on the road in India. The question is where would they go? A nation cannot put most of itself on the dole, even if money and food are available for distribution. And for at least half a century—possibly much longer—neither the city slums, nor the industrial sector of the Indian economy, whatever its rate of expansion, would have the space or capacity to absorb an influx of so many displaced and virtually unemployable people. Even if the entire urban-industrial complex of the U. S. were transported to Indian soil, it would not cope with the problem.

The urban centers will be in difficulty with the natural increase in their own population. Assuming that there is no change (from 1961) in the birth rate and in the sectoral distribution of workers, industry would have to provide additional employment for 22. 1 million hands by 1975. The corresponding figure for agriculture would be 56. 4 million. Farm workers would have increased from 135. 3 million to 191. 7 million in 15 years. If their proportion to the total labor force were to decline by even 5 percent in this period, 35. 8 million new jobs would be needed in the urban sector, while agriculture would still have to absorb another 42. 7 million workers. These are some of the givens that cannot be altered.

In India increase in agricultural production is required not only to eliminate imports and stock the grocery stores, but also to improve the purchasing power of the majority of the people who live in the rural areas. They constitute 82 percent of the population, and their poverty is as staggering as their numbers. Their welfare, and the contribution their purchasing power could make (or fail to

make) to national growth are clearly of major importance. To expand agricultural output by reducing tens of millions to refugees without a refuge, would be simple. In the Indian situation, however, the resulting disequilibria would not be in the nature of residual problems of growth, mere lags in adjustment that could be consigned to the police, psychologists, and welfare agencies, as in the U.S. They could overwhelm and destroy the total fabric of society, economy, and the state.

Concentration Not Inevitable

This does not mean that Indian agriculture should not modernize, or should merely await economic development in general, which would relieve the pressure of population from land. Modernization of farms can be done prior to, or simultaneously with overall development, and without creating a surplus of manpower. But technology, tools, markets, rural institutions and services will have to be designed accordingly, to subserve the resulting scale and level of skills, and primarily to increase output per unit of land.

For two of the most important yield-increasing components of modern technology, seeds and chemicals, scale is not even relevant. The smallest farm can use fertilizers and pesticides as efficiently as a large operation, or more so. Irrigation too is neutral to size. And just as farmers do not own large projects that distribute water to millions of acres, so each need not possess his own tube well. The only production factor to which the scale of operation is crucial, and which farmers are generally averse to owning or operating jointly, is farm machinery. It is not essential, however, that machines be large, unless the goal is to save man-hours and substitute capital for labor. If the average size of operational units is fixed and inflexible, equipment can be designed, improved, and made increasingly efficient to operate within the limits of the given acreage. Neither large machines nor large farms are indispensable to "modernity" or efficiency in agriculture; when and if the farmers become fewer and the farms can be bigger, the machines could be changed. But machines must not be permitted to determine the economic scale of efficiency, and thereby liquidate the small cultivator or prevent him from participating in the varietal and chemical revolution now underway.

The problem of quality and managerial skills also is tied in intimately with machines and scale. For example, a small farmer I interviewed in South India, Nagamuthu, would have no difficulty in using an improved plow or a small power tiller. He could learn to drive a tractor. But he would not be able to manage the economies of a farm that could use a fifty-horsepower tractor. When I pressed him further to explain why he would not like to own more than 1.3

acres, his reply was that he could not cultivate any more land with family labor. If he had more, he would have to hire help. But that would involve financial and managerial responsibilities that he did not think he could handle. Aside from that, Nagamuthu is conversant with every cultural operation that the new seed requires. He has been using irrigation, fertilizers, and pesticides. None of the new practices would be beyond his educational level; he would have to be induced mainly to do more of exactly the same operations better, with greater precision.

Japanese Example

That modern units of agricultural technology can be exceedingly small and yet produce the most that any seed and soil are capable of yielding is clearly demonstrated in Japan. Comparing two of my informants: on 0.16 hectares of poor soil in Gumma Prefecture in central Japan, Susumu raised more rice per hectare than Russell Carrino did on a farm over a hundred times as large in the salubrious climate and fertile soil of California. He used more than 50 times the number of hours to produce a unit of rice than did Carrino, and on a per acre average he applied more fertilizer and pesticides than the American farmer. He also used irrigation and quality seed.

It is clear that minute farms with very modest capital and operating expenses can be viable commercial units. For instance, farm households operating less than 0.3 hectares each in Japan, marketed 38.4 percent of their produce. Farms in the range of 0.5 and 1.0 hectares each, sold as much as 63.3 percent of their output. They produced for the market. Of all farms 51 percent had sales exceeding 100,000 yen in 1961; most of them were between 0.5 and 1.5 hectares each. Fujita, Takeo, Kyuzo earned million-yen incomes from such farms [360 yen = $1]. Furthermore, despite modernization, Japan still had roughly twice as many farms as does America, and on a total land surface smaller than California. And there were no surplus farmers, no class of landless agricultural laborers.

Even though it cannot be repeated, the history of Meiji Japan could be instructive in several respects. The entire subsistence sector of the farm population, for example, was commercialized at a stroke, so to say, by the conversion of the agricultural tax from kind to cash and from share to fixed, along with the appropriation of monopoly control by the government over the production and sale of sake, tobacco, and salt. Even the smallest peasant was compelled, thereafter, to produce a portion of his product for sale in a free market. Again, the differential pricing and procurement policy of 1941 reduced the percentage of non-cultivating farmers dramatically, by making it unprofitable to be a landlord. Similarly, sheer economies of scale and efficiency had reduced the size of operational

holdings to a uniform average of one hectare, a century prior to the land reform of the postwar period.

Application to India

If the future scale and pattern of commercial farming in India is to approximate that of Japan, it will require a radical shift from the approach underlying the Indian government's High-Yielding Varieties Program of 1966. The national goal then will have to be, not to modernize a decreasing number of farms in a few favored regions to increase production endlessly, but to modernize the total farm labor and upgrade its operative efficiency.

Whereas less than six million farms of adequate size could produce all that the Indians could consume and more, the number of agricultural workers will have exceeded 170 million by 1970. It would be impossible to equate the two. Production plans, therefore, would have to be formulated primarily in terms of farmers, not acres.

It would be legitimate to ask: is it possible to transform 60 million or more "traditional" peasants into "modern" commercial farmers? Can it be done? The answer will have to be sought not in the marginal productivity of another ounce of nitrogen in the production of rice, nor in farm factor and product prices, though these will always be pertinent, but in a clear comprehension of the production behavior of the cultivator. To return to the original query then, with which this study began: Why do farmers, any farmers anywhere, work and produce as they do?

Why did Ayyar, Vishwalingam, Kodandpani, and Nagamuthu in south India not do everything that they knew they should and could to increase their yields by as much as one to two thousand pounds of rice per acre? Ayyar alone was foregoing an income from fifty thousand pounds of paddy from just his portion of the land; his family, three times as much. Ayyar never steps into a field and blames the low output on his tenants and wage workers. But Vishwalingam works on land that he owns. Similarly, the owner and tenant, Kodandpani and Nagamuthu, would share the profit from higher yields. All four farmers would have gained directly and immediately from increased production. It would be difficult to imagine a Japanese cultivator—Susumu, Takeo, Kyuzo or Yamayasu—letting such opportunities go by. On the average, they were producing more than three times as much as the Indian farmers. Yet, they would have "sweated for even one extra koku of rice."

A high-yielding variety of rice requires more of precisely the quality and timeliness in the performance of various cultural

operations that these Indian farmers were neglecting presently. The new rice yields well only under optimal conditions of care and environment. The seed bed must be prepared with extreme care. Transplanting must be done on time. Fertilization must be heavy, exact, and correctly applied. Many more weeds, and pests and diseases must be checked and eradicated effectively. The new seeds, then, have the effect of accentuating differences in the rewards and punishments for differential farmer performance. At the same time that they open larger possibilities for small farmers' production, they raise the survival stakes.

Some International Inferences

The mere fact that agriculture could be such an outstanding success in Japan and the United States clearly establishes that it is possible for farmers to work and produce equally well under almost diametrically different resource and environmental conditions—cultural, political, economic. Within American agriculture, however, and, unlike Japan, there is evidence of wide and significant variations in the production behavior of individuals and communities having access to similar and plentiful resources, incentives and opportunities, often within the same region and type of farming. Inefficient methods can survive; for example, no modern steel mill could operate the equivalent of the substandard dairy plant that Robert owns in Wisconsin, with similar substandard efficiency, and stay in business.

The still backward economy of India offers many more choices than does either the United States or Japan of routes, goals, norms, techniques. And for the great majority it offers a survival floor that is practically a bottomless pit. There is no level of inefficiency so low that a cultivator cannot operate at it. This accounts for the abysmal state of productivity nationally; in 1962 India produced half as much, or less, rice per hectare than Japan did in 1882. It is also responsible for the striking variations in farmers' responses and behavior, as reflected in the rate and pattern of increase in agricultural output in the first decade and a half of planned effort. The variations were considerable between farmers in the same or neighboring villages; between districts within a state; and between the states themselves.

If farmers can act so differently within the same opportunity environment in the same country, then the beliefs and attitudes that condition and determine the quality and extent of their economic effort and its efficiency are not inborn, universal, or immutable. Given the choice of a dozen routes, all farmers will not, and cannot be expected to take only one and the same route. If they do, it will be a coincidence.

In India it is imperative to achieve a modernized pattern of production with some 60 million cultivators producing predictably. Ideally, they would perform in a similar manner and measure to fulfill preset targets according to a plan. If their attitudinal and behavioral differences are significant, however, they could introduce elements of uncertainty so large as to make nonsense of all planning. And the differences will not disappear if simply one more possible route is added to the dozen and made somewhat more attractive than the rest. Some will take it, but not all, or even the majority, necessarily. On the contrary, the only feasible solution would lie in cutting off the unwanted eleven of the twelve choices.

Within the framework of a given technology, the level of operative efficiency will be determined not by the Olympian heights of the potential of production and profit, but by the floor of economic and technical feasibility and social expectation below which it is impossible to farm. And the scale and spread of efficiency among cultivators will depend upon whether this floor is the same for all, or different for various strata and sections. In Japan, farmers have had few resources and, till very recently, even fewer choices within agriculture. For nearly three centuries they have had to grow all they could, as efficiently as possible, or quit. The performance floor for survival has been extremely high for everyone.

In India, fiscal measures relating to prices, taxes, credit, wages, tenurial arrangements, procurement and marketing regulations for farm inputs and commodities, institutions, norms, and ideologies could be used, separately and together, to induce the necessary changes in the structure and techniques of farming. It should not be feasible for Ayyar to own land and not enter his fields and not work himself; for Vishwalingam to go away to any wedding but his own when he should be transplanting the rice or applying fertilizer; and for Nagamuthu not to weed the paddy. In effect, and for whatever the reason, it should be impossible for anyone to farm and not produce at least as much as he knows he can. And then, perhaps, he will try also to produce a little more.

[Adapted from The Lonely Furrow: Farming in the United States, Japan and India. Ann Arbor (Mich.): The University of Michigan Press, 1969, Chapter 29, pp. 220-234.]

FOOD FROM THE SEA

FISH HATCHING.
(PHOTO: U. S. DEPARTMENT OF AGRICULTURE.)

Food from the Sea

George Parman

[The overall potential for food production from the sea is vast. Use of fish in meal for animal feed and in protein concentrate for humans are opening up new markets, and further gains could come from increased knowledge of fish nutrition and breeding.]

The oceans are a large plain covering 71 percent of the earth's surface. They represent a new frontier where food, mineral wealth and space are available for exploitation by man. The solar energy falling on this plain and acting as much as 100 ft. below its surface is converted, in part, to organic matter in the form of phytoplankton. This microscopic floating plant life in turn supports large schools of fish and other marine animals. Until comparatively recently, these were hunted as food by a relatively small number of people. The vast majority, then and now, live and die in the complex web of the life cycles of the ocean.

Potential of Sea Resources

By using the decay rate of carbon isotopes it has become possible to measure the rate of fixation of carbon into the living material of the oceans. Enough measurements have been made to permit a conservative estimate of 19 billion tons of carbon per year being fixed into living matter in the oceans by photosynthesis. This represents about 700 billion tons, wet weight, of plankton (living organisms). Most of this is produced in the form of microscopic plants called

Mr. Parman is Director, Food from the Sea Service, Office of the War on Hunger, U.S. Agency for International Development, Washington, D. C.

phytoplankton. The concentration of phytoplankton, even where it is growing so thickly as to color the water a deep green, is still so dilute that direct harvesting is economically impossible. We must rely on its concentration by fish or other marine organisms which can then be used by man.

The efficiency of transfer of energy from phytoplankton to herbivores (plant eaters) and to first-stage carnivores (meat eaters) and further down the chain is not known with precision, but it appears to be between 10 and 20 percent. Dr. Schaefer of the University of California at San Diego has calculated the potential harvestable yields of the ocean at differing efficiency levels, based upon the 19 billion ton estimate of carbon (see above). The herbivorous fish and marine animals—those that feed directly on phytoplankton, such as anchovy, copepods, etc.—at a 10 percent ecological efficiency factor will yield 19 billion tons and at a 15 percent factor will yield 28 billion tons per year. At the first stage of carnivorous level (fish that live on zooplankton, for example herring and sardines), a 10 percent ecological efficiency factor will yield 1.9 billion tons and a 20 percent factor will yield 7.6 billion tons of crop. Going one stage further, with carnivorous fishes such as mackerel, most tuna, some salmon, cod, etc., which live on herring and sardine, a 10 percent econological factor will yield a 1.5 billion ton crop. The closer the fish are to the phytoplankton as a direct source of food, the greater the potential yield because of a greater efficiency of energy transfer.

There are large resources of first-stage carnivore fish in the tropical and subtropical seas which have hardly been tapped as yet by man, but are becoming well known through ocean research. As a conservative estimate, Dr. Chapman of the Van Camp Sea Food Company has set 2 billion tons as the potential sustainable harvest that could be produced from the sea each year of the sizes and kinds of organisms now being caught and utilized by man. This contrasts with the 60 million tons caught in 1967.

If we assume a current world population of 3 billion people and figure that each person needs about 50 gm. of animal protein per day (this is high), the total amount of protein required per year is 55 million tons. Assuming that fish contain approximately 20 percent protein on a dry weight basis, 2 billion tons of fish produce would provide about 400 million tons of animal protein, more than seven times the total protein requirement of the present human population. More conservative estimates, differently derived, place the sustainable harvest in the 200-300 million tons a year bracket; this would just about supply the world's animal protein need at the 50 gm. per day level.

The potential of the ocean exceeds present demand, so there is no pressure on the fish population as a whole even though there are local areas of overfishing. With more knowledge of the ecological factors involved and with increasing maturity in international cooperation, the wild stocks can be maintained. We need not worry about overfishing if we use our intelligence.

Fish Farming

Except for carp and goldfish, we don't really have any fish that can be said to be domesticated in the sense that we have domesticated the cow and the sheep. However, there is extensive farming of higher priced fish and other marine animals, largely for the affluent markets of the world. Oysters have long been farmed, particularly in Europe where very extensive areas of river estuaries are used for this purpose. In Denmark and in the western United States there are many trout farms. In Arkansas there is a very considerable amount of farming of catfish and the output is sold at 70¢/lb., a level which will make some chicken farmers think seriously about going into fish farming. Some attempts have been made to farm lobster, but they are such aggressive animals that the crop is largely destroyed because the lobsters fight among themselves.

In the Far East there is extensive farming of fresh water fish. This is an ancient art the Japanese and Chinese have practiced for centuries using carp as their main fish. In the Philippines, the raising of small fish in the rice paddies is extensively practiced. These fish multiply and grow quite well in the paddies and are harvested simply by picking them off the ground when the paddies are drained prior to harvest. When dried, they provide a considerable contribution to the protein resources of the rice farmer. They also help considerably in keeping down the mosquito population.

Undoubtedly, other species could also be farmed. However, as long as there are still adequate wild stocks available and as long as they can be taught relatively easily, there is really no strong economic impetus for going into fish farming.

Increased Demand

Since 1948, there have been marked changes in the form in which fish is used. The tonnage of fish used in fresh form has decreased as a percentage of the total catch from 49 to 33 percent. Frozen fish has developed steadily from 1 million tons in 1948 to 5 million tons in 1964, the latter representing about 10 percent of the catch. Dried, smoked and salted fish, the old traditional way of preserving fish, declined from almost 25 to 16 percent of the catch in 1964. Canned fish totaled 4.4 million tons in 1964, a modest increase to about 8 percent of the total catch.

As refrigeration and freezing facilities increase, the percentage of fish sold fresh will show a corresponding increase. We can be certain that as societies get more affluent, demand for good quality fresh fish will show an increase. Canned fish seem to have a more limited expansion. The greatest difficulty is the high cost of the cans, which is a real deterrent in many countries. The biggest single factor in the increased overall demand for fish has been fish meal for animal feed use. In 1948, 1.5 million tons of fish were used for fish meal production, and in 1964, 15.4 million tons.

The utilization of fish as fish meal has unique advantages. Many of the untapped fishery resources are sardines and similar small fish. Their direct use by humans is difficult because of their small size; the can ends up costing more than the fish it contains, and the ultimate price of the canned product is beyond the reach of the people who would most benefit by it. On the other hand, fish meal can be produced at very low cost from fish like sardines and needs only to be bagged in burlap sacks to keep satisfactorily for a considerable period of time. When added to animal feeds at levels from 3-7 percent, it significantly aids in improving meat, egg or milk production, without adding to the cost of these popular food items.

Another advantage in the utilization of fish meal is that it minimizes difficulties with acceptability. For a variety of reasons many people will not eat fish. For example, there are millions of people in India whose religion forbids them to eat flesh of any kind, but there is no objection by these people to fish meal being fed to their milk buffalo so that the buffalo produces more milk.

There is no doubt that the use of fish meal will increase enormously. Not only will there be the increasing demand in the existing markets, but we are already witnessing the beginning of substantial demands in the developing countries to meet the needs of the animal feed industry.

Fish Protein Concentrate

The popularity and usefulness of fish meal have inevitably led to considering a similar product for direct human use and much effort has been spent in developing a suitable concentrate of this kind. Theoretically, a concentrate of high protein content can be obtained, and potentially this can be made from large fishery resources, many of which exist near areas of great protein need. A protein concentrate of this type would have many of the advantages of milk as an animal protein and would be useful in most, if not all, of the places where milk is used. This ability to substitute for milk is important because milk is not available in all parts of the world and, in fact, the supply of milk per capita is tending to decrease rather than to increase.

The fish protein concentrate produced by the process developed by the Bureau of Commercial Fisheries of the U. S. Department of Interior is a grayish white powder containing 80 percent protein, approximately 14 percent minerals and balance of residual water. The product is odorless and has no fishy taste, although it does have a slight characteristic protein taste, not unlike a somewhat salty casein. The essential value of this product is as a protein supplement to enhance and improve the quality of basic vegetable protein sources, for example, to improve the quantity and quality of protein in flour.

Fish protein concentrate must be made from whole fish to be economical. If the product is made from sardines, for example, which represent a tremendous resource, it is physically and economically impossible to consider cleaning and deheading the millions of sardines that would be processed per day. Fish protein concentrate appears to be capable of being made at about 25-30¢ per lb. At this level, it becomes the cheapest animal protein supplement. There is much to be done, however, before fish protein concentrate will have a good commercial acceptance. Extensive acceptability and feasibility studies will be necessary to determine where and how the production may best be used.

New Possibilities

Looking to the future, other fish protein concentrates offer some unique possibilities. The so-called fish sauces that are so popular and widely used in Southeast Asia are in effect fermented fish products. The fermentation is a mixture of enzyme activity from the fish plus bacterial action and the resulting products often have very interesting, if somewhat pungent, tastes. By using different organisms and more sophisticated techniques, it appears possible to ferment fish to make protein concentrate with a variety of highly interesting flavors. Very preliminary work has produced products tasting like beef extract, cheddar cheese and celery.

Probably the most impressive gains in the future will be made through an increased understanding of how the large populations of fish in the oceans can be maintained at peak production capacity. As we get a better idea of the growth of phytoplankton, particularly its nutrient needs, it may be possible to provide fertilizer in some form that will enhance the growth of this basic marine energy source.

It may also be possible to consider genetic improvement of the fish herds. This is already being done in the Great Lakes, where a cross between the lake trout and the brook trout called splake is being stocked. This cross reaches maturity more rapidly than lake trout and may have better ability to resist the depredations of the

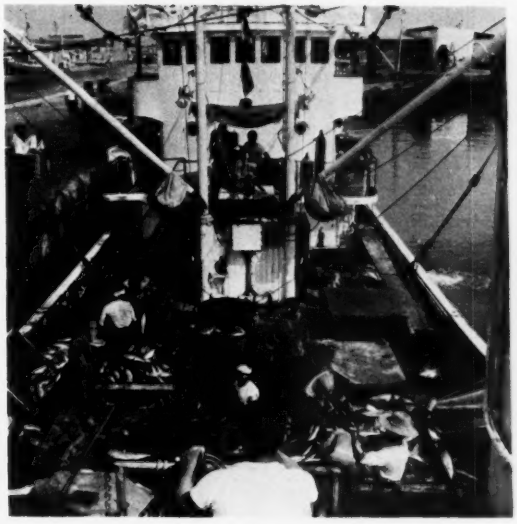
sea lamprey, which has largely killed the lake trout in the Great Lakes. One could visualize a similar genetic improvement in herring, anchovy or cod.

Another area that has great promise is the utilization of some of the presently untapped sources in the ocean. There are huge amounts of krill, a form of shrimp in the Antarctic seas which might be a new source for fish meal or for some type of protein concentrate. The giant squid family is another source that is currently not utilized to any great extent.

There is no doubt we have an enormous food potential available from the seas. Even with present technology, this potential can be utilized effectively. There seems little doubt that with the type of research that has made our agricultural production increase so remarkably, it would be possible to use the oceans for centuries to come to produce adequate and nutritious food for the world's growing population.

[Excerpted from Feedstuffs. Minneapolis: Miller Publishing Company, Vol. 39, No. 5, 4 February 1967, p. 66.]

Right: Japanese tuna ship unloading in Tema, Ghana.

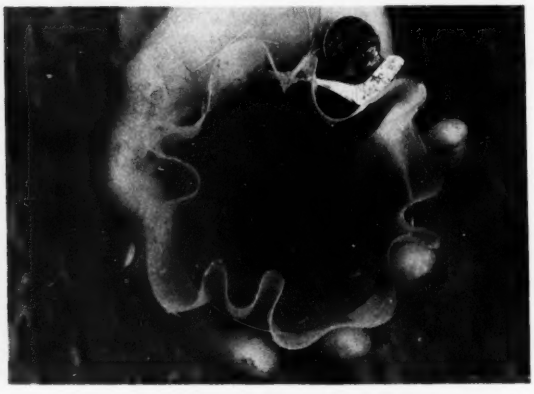


Below: Large prawns packed in ice for shipment to U. S. market from Guyana.

Above: Community fish pond, Orissa, India.

Right: Coastal fishermen with catch, Maharashtra, India.
(Photos: FAO)

Left: Peru, with world's largest catch, makes most of it into fish meal. Fish meal bags outside factory, piled up ready for export. (Photo: FAO)



Above: Plankton, sole food of Peruvian anchoveta. (Photo: FAO)

Right: Cultured catfish being harvested and weighed for shipment by truck, Arkansas, United States. (Photo: U.S. Department of Agriculture)

Left: Dragger ship for scraping oysters off bottom of sea, France. (Photo: National Council on Marine Resources and Engineering Development)

The Management of Fishery Resources

Food and Agriculture Organization
of the United Nations (FAO), Rome

[Rapid increases in post-war fishing efforts, using factory processing ships ranging far into new oceans, are depleting stocks in many areas. Management of overfished stocks in accordance with biological principles will be increasingly needed to maintain food supplies.]

The estimated world production of fish has tripled in the last two decades (see Table 1). Peru, Japan and the USSR have contributed much of the increase. This growth is considerably faster than that of either the human population or the overall production of food. In the world as a whole, fish contribute about 10 percent of the total animal protein intake, but considerably more in some areas such as the Far East (27.5 percent).

Today's big catches, due to increased local fishing and especially to the rapidly increasing number of mobile factory and other vessels operating far from their home base, have intensified the problems of overfishing. In 1949, the only overfished stocks were those of a limited number of high-priced species, mainly in the north Atlantic and north Pacific; some 30 stocks were then believed to be underfished. Of these 30 about half are now in need of proper management, including cod, redfish and herring in the north Atlantic, and at least some species of tuna in most of the oceans.

The problem of international management is becoming increasingly urgent. The classical response of the fishing industry to overfishing in one stock has been to move to other usually more distant stocks,

Table 1: World Fish Catch

(in millions of metric tons)

	1948	1953	1959	1963	1965	1967
TOTAL	19.6	25.9	36.7	48.3	53.5	60.5
Africa	1.0	1.7	2.3	2.8	3.1	3.7
North America	3.6	3.7	4.3	4.4	4.5	4.3
United States	2.4	2.7	2.9	2.8	2.7	2.4
Canada	1.1	0.9	1.1	1.2	1.3	1.3
South America	0.5	0.6	3.0	8.4	9.0	12.1
Peru	0.1	0.2	2.2	6.9	7.5	10.1
Chile	0.1	0.1	0.3	0.8	0.7	1.1
Asia	6.8	10.6	16.2	19.5	20.7	22.6
Japan	2.4	4.6	5.9	6.7	6.9	7.8
India	n.a.	0.8	0.8	1.0	1.3	1.4
Mainland China	n.a.	1.9	5.0	n.a.	n.a.	n.a.
Europe	6.1	7.2	8.2	9.0	10.9	11.8
Norway	1.5	1.6	1.6	1.4	2.3	3.2
United Kingdom	1.2	1.1	1.0	0.9	1.0	1.0
Spain	0.5	0.6	0.9	1.1	1.3	1.4
USSR	1.5	2.0	2.8	4.0	5.1	5.8
Oceania	0.1	0.1	0.1	0.2	0.2	0.2

Source: United Nations Statistical Yearbooks, 1965 and 1967. As far as possible, data cover both sea and inland fisheries. Table includes countries with catches of one million tons or more. The last figure for Mainland China was 5.8 million tons in 1960.

but it is clear that this process cannot continue much longer. There are some recently discovered resources, such as oil sardine and Rastrelliger in the Arabian Sea and hake off the west coast of the Americas, but most of these additions have been in the Indian Ocean and eastern Pacific areas away from the major centers of fishery development. At the present rate of development few substantial unexploited stocks of fish accessible to today's types of gear will remain in another 20 years.

The problem of overfishing arises because fishery resources generally have no ownership. Next year's catches depend on how much is taken this year, but in the open sea the individual fisherman can do little to ensure better fishing for himself next year—if he does not catch fish while he can, someone else will. Thus effective manage-

ment depends on the participation of all or at least of the great majority of those exploiting a given stock of fish. The problems are more complex when many countries are concerned or when more than one species of fish are caught—especially when there may be biological interactions between the stocks, for example when one species is the main food of another.

Changes in Fish Stocks

A hundred years ago most people, including leading scientists, believed that the living resources of the sea were essentially inexhaustible—"there are more good fish in the sea than ever came out of it." This assumption, which was justified at the time considering the fishing fleets then contemplated, has been invalidated by the subsequent intensive exploitation of many of the world's most valuable species. Convincing proof that these declines in stocks were due to fishing was provided by the severe restrictions on fishing during the two world wars. Immediately after each war the catches of individual trawlers were raised, often to several times the pre-war averages. This, and similar experiences elsewhere, shows clearly not only how fish stocks can be depleted by fishing, but also that the process is reversible. Thus, with proper management, stocks can build up again, even such vulnerable stocks as whales: for instance, the southern right whale is returning to New Zealand waters. One example of an important stock being rebuilt by regulation after becoming seriously depleted is the Pacific halibut.

Changes in Fishing Effort

In the last decade there has been a further expansion in European fishing, with increasing numbers of new widely-ranging freezer and factory trawlers. This expansion of fishing capacity was directed to the northwest Atlantic. More recently the major expansion in European fishing has been in the central and south Atlantic, particularly off the west coast of Africa. Expansion by industrialized countries has taken place both directly through increasing numbers of larger and long-range freezing and factory ships, especially from eastern European countries, and also indirectly through investment in locally based fleets in the coastal countries of west Africa. In addition these countries are developing their own offshore fisheries.

Similar developments have taken place in the other oceans, particularly in the northern Pacific, where Japanese and more recently USSR fisheries have been expanding further and further afield. In certain areas European and Japanese vessels are exploiting the same stocks, such as hake off the southwest coast of Africa.

Despite continuing improvement in fishing methods, fishing gears now in use are fundamentally the same as those of 50 years ago—seines, trawls, and hooks and lines. The types of fish being caught are also the same. They are species which are found in concentrations, either in large shoals in the open sea such as anchovy or sardine, or on the sea bottom such as cod and flounder; or they are large animals, such as tuna and whales. Unless there is a technical breakthrough which would make the harvesting of new types of resources economically feasible, the present rate of expansion of world fish production cannot be maintained indefinitely, possibly for not more than 10 or 15 years. The proportion of the total world catch which comes from heavily exploited stocks needing proper management will rapidly increase, and it will become increasingly difficult to avoid the problems of proper management of an overfished stock by turning to others which are less heavily exploited.

Biological Basis of Management

In the absence of fishing, a stock of fish will be large and will include a relatively high proportion of big and old individuals. The increase in the total biomass due to growth of the individuals and the recruitment of young fish will be balanced over a period by the losses due to natural deaths. When fishing begins, the large stock gives large catches to each vessel but, since the number of pioneering vessels is generally small, the total catch is also small; losses due to natural deaths will be less than gains due to growth and recruitment. If the catch taken is equal to this surplus, the stock will not change; any catch greater than this sustainable yield will decrease the stock, while a smaller catch will allow it to increase. This sustainable yield is small at very large stock levels because natural deaths are only just less than the growth and recruitment; equally it is small at very small stock levels where the absolute value of the increase due to growth and recruitment is small. Thus the greatest sustainable yield will be taken at some intermediate stock level.

This level may be achieved by some moderate amount of fishing on all sizes of fish, or possibly quite heavy fishing selectively applied to larger fish. The greatest catch from a given brood is taken by allowing the fish to attain a reasonable size by using some selective gear, such as trawls with large meshes, that will catch the larger fish while allowing the small ones to escape and grow.

[Excerpted from The State of Food and Agriculture 1967. Rome: FAO, 1967, Chapter IV, pp. 119-125.]

Status and Potential of Aquaculture

John H. Ryther and John E. Bardach

[The practice of aquaculture could be greatly improved and expanded, particularly in those parts of the world most in need of its products. Existing techniques are available for immediate application and quick return. But the application of scientific methods holds still greater promise for the future if research and development capabilities are brought to bear on the problem.]

The culture of aquatic organisms, in contrast to their capture from untended stocks, is practiced in many parts of the world. If we include in aquaculture any operation that subjects the organisms in question to at least one manipulation before their eventual harvest or capture, the total tonnage so produced may lie between 5 and 10 percent of the total world fish catch. Most of this is found in fresh or brackish water; intensive fish culture in waters of full marine salinity is in its infancy, but some true marine husbanding operations are being attempted, most notably in Japan, the Soviet Union and Great Britain.

It is possible today to produce significantly larger amounts of high grade animal protein per unit of inshore or freshwater surface than on fertile dry land. The reasons for this may be found in some basic biological and ecological principles. Aquatic organisms live in a medium of about the same density as their own. Hence they require less skeletal structure for their support than needed by birds and terrestrial

Dr. Ryther is with Woods Hole Oceanographic Institution, Woods Hole, Massachusetts. Dr. Bardach is with the School of Natural Resources and Department of Zoology, The University of Michigan, Ann Arbor.

mammals, with a correspondingly greater percentage of their assimilation devoted to the production of edible musculature. The metabolic advantage of aquatic animals lies in their not having to expend a portion of their caloric intake in maintaining a constant body temperature. Sessile organisms which cannot move, or animals constrained in enclosures, which feed on plankton have an added advantage. The oysters on 1 acre of sea bottom have access to the food from thousands of acres in the water flowing past them. Currents and tides serve the meals up to the animals, not only giving them the produce of a huge area but sparing them the metabolic cost of gathering it. Admittedly, these are over-simplifications, but in principle they are the reasons that, while a few hundred pounds of beef cattle can be raised in an acre of very good pasture, a ton or more of fish and a hundred tons of shellfish may be cultivated in the same aquatic area.

Aquaculture has made significant advances in some parts of the world. The species which have been selected for culture are those which bring the highest price to the culturist, the so-called luxury foods. A high-priced market may be the initial incentive for the culture of a species, and may justify the investment of research and development funds by the individual or firm involved. Were it not for this, the field would not have developed as far as it has.

The species in culture, with the exception of mollusks and a few kinds of fish, are predominantly carnivores or omnivores two or more levels in the food chain above the photosynthetic base. Each step in this progression involves a loss of about 90 percent in the conversion from food to new animal tissue, which affects production costs. Higher level carnivores can be produced profitably in cases where the product is extremely valuable, or where the food may be obtained cheaply. Examples are the culture in Denmark of rainbow trout, which are fed small herring and other trash fish from the North Sea, and in Japan of shrimp, which are fed small shellfish, fish, and shrimp of low market value. Progress is now being made in compounding land-produced waste foodstuffs, fortified with the necessary animal proteins and vitamins, into cheap and readily-available food for fishes. Such practices can be comparable to the mechanized, mass production of chickens with fish meal and other prepared foods; chickens have been reduced from a high-priced luxury food to an inexpensive staple meat product. Thus, with the help of modern technology, even carnivorous species of fish may be reared in culture economically, producing large quantities of high-quality, protein-rich, and low cost food.

However, for the cultimate objective of increasing the protein supply of the world it is the herbivorous species which should be utilized. In contrast to land forms, they utilize microscopic plants

which have, thus far, proven to be in themselves unharvestable and unusable by man. Almost staggering amounts of certain shellfish can be produced even with existing techniques, e.g., using ropes hung from rafts, as in Spain. An area of 1,000 square miles, roughly the size of Long Island Sound, if ecologically suitable and managed intensively for this purpose alone, could produce annually an amount of mussel meat equal to three times the total fish catch of the world.

Yields in Aquaculture

We may establish the following categories in aquaculture, in ascending intensity of labor and capital input (Table 1 gives selected examples of yields for each category):

1. Transplantation of species from poor to better growing grounds (Denmark) and introduction of species into new environments, also to include selected food organisms of these species (Soviet practices). It is believed that this method of extensive culture shows little economic promise.

2. The stocking of hatchery-reared juveniles for augmenting and replenishing natural stock as practiced with the various anadromous salmon species. Recent advances in hatchery techniques have made this practice assume favorable cost-benefit ratios.

3. Enclosures in which organisms are retained in the sea, or devices on which they are affixed, either by themselves or being placed there after collection (prawns in Malaya); the water in the enclosures is not fertilized, nor are the animals fed. Mollusk culture falls into this category, as does the culture of marine algae in Japan.

4. Ponds or enclosures shut off from the sea which are fertilized (milkfish in Southeast Asia, certain Tilapia cultures in Africa and the Near East).

5. Enclosures and ponds in which the animals are raised with fertilization of the water and with additional food supplied to them (catfish culture in the U.S., culture of Chinese carps in China and the Far East).

6. Enclosures, often of cement, in which the animals are raised by extraneous feed only, somewhat comparable to the intensive chicken raising methods in the U.S. and Europe. Volume of flow rather than surface is important in this category (trout and salmon culture in the U.S. and Europe; shrimp, carp and eel culture in Japan; experiments with plaice and sole culture in Great Britain).

Table 1: Summary of Aquacultural Yields with Ascending Intensity of Culture Methods

(Units in Fresh Weight, Shells of Mollusks Excluded)

Location	Species	kg/ha/yr*	Local Wholesale value $U.S./acre*
I. Transplantation of Species:			
Denmark	plaice	n.a.	n.a.
II. Stocking of Hatchery - Reared Juveniles:			
Great Britain	plaice, sole	---	---
Japan	shrimp, crab, abalone, sea bream, puffer fish, Pacific salmon, others	Benefit/Cost Ratios: 3.5-5.5:1	
U.S.	lobster, Pacific salmon	---	---
III. Cultivation of Stocked or Natural Populations, No Fertilization or Feeding:			
U.S.	oysters (national average)	9	16
	oysters (best yields)	5,000	9,000
France	flat oyster (national average)	400	2,000
Australia	oysters (national average)	150	170
	oysters (best yields)	540	6,250
Japan (Inland Sea)	oysters " "	20,000	28,000
France	mussels " "	2,500	750
Philippines	mussels " "	125,000	8,000
Spain	mussels " "	300,000	20,000
Japan	Porphyra (seaweed)	7,500	3,000
Singapore (elsewhere in Southeast Asia)	shrimp	1,250	600
IV. Stocking and Cultivation: Fertilization, No Feeding:			
Taiwan	milkfish	1,000	---
Southeast Asia, Israel	carp (related species)	125-700	---
Java (sewage streams)	carp	500,000-750,000	---
Africa	Tilapia	400-1,200	---
Japan	Chlorella (alga)	325,000	none
V. Stocking and Cultivation: Fertilization and Supplemental Feeding:			
U.S.	catfish	3,000	1,000
China, Hong Kong	carp (related species)	3,000	---
Israel	carp, mullet	2,100	---
VI. Stocking and Cultivation, Running Water, Intensive Feeding:			
U.S.	rainbow trout	over 2,000,000 (170kg/liter/sec)	(168 per cubic ft/sec)
Japan	carp	1,000,000-4,000,000 (ca 100kg/liter/sec)	---
Japan	shrimp	6,000	18,000

*Production figures per hectare or per acre may appear misleading as highest yield cultures are often practiced on small areas.

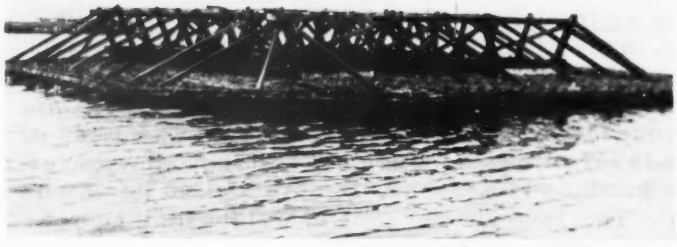
Intensive pig farming in developed nations leads to a production per man-year of around 25 tons of live pigs while an oyster farmer can raise 40-60 tons (shells excluded) per year. The average Danish trout farm produces about 40 tons of trout per year, with two or three men employed to do the labor. The sewage ponds of the Bavaria Power Company, near Munich, can produce 100 tons of carp from about 200 hectares of water. Three men tend the ponds and the fish; fish production per man-year would exceed 30 tons. On a well designed Idaho trout farm, with an ample year-round supply of isothermal water, the labor of one man per year may produce over 100 tons of fish (if the produce is dressed, the production per man falls to 40 or 50 tons). The revenue per unit of weight may be reasonably compared to that from a unit of pig flesh.

Projections for Expansion of Aquaculture

Several-fold gains in total tonnage per unit surface could be expected through the uniform application of best presently known practices. Fisheries biologists at the Food and Agriculture Organization of the United Nations (FAO) made a projection in 1966 of aquacultural possibilities on this basis: they reviewed the opportunities of upgrading management techniques as they apply to very extensive, semi-intensive and the most intensive methods of fresh and brackish water fish culture. Their estimates range between a 5 and a 15 to 20-fold increase as a possible goal to attain within the next 35 years. Realization of this goal will depend, however, on the application of biological and engineering skills, on the creation of economic incentives and on the removal of social, administrative and political constraints.

The total fresh and brackish water fish production (FAO Yearbook, Fishery Statistics, 1965) of the world is around 7 million metric tons; only vague guesses are possible on the percentage of this tonnage raised by fish culture. Mainland China alsone reports a pondfish production of 1.5 million tons (the world's largest cultured fish output), and the rest of Southeast Asia, Africa, the Near East and Europe probably produce somewhere near another 500,000 tons. Considering that freshwater fisheries statistics, especially of developing nations, have been estimated to fall sometimes 50 percent short of the real supply, the fresh and brackish water fish raised under culture may perhaps reach 3 million metric tons. Taking the mean value of possible increases estimated by FAO one might look, by the year 2000, for a pondfish production that is 10 times the present one, namely 30 million metric tons.

Another important area of expansion would lie in bringing into culture areas that are suitable but are not now utilized for aquaculture. Assessment of such areas has not been attempted on a world

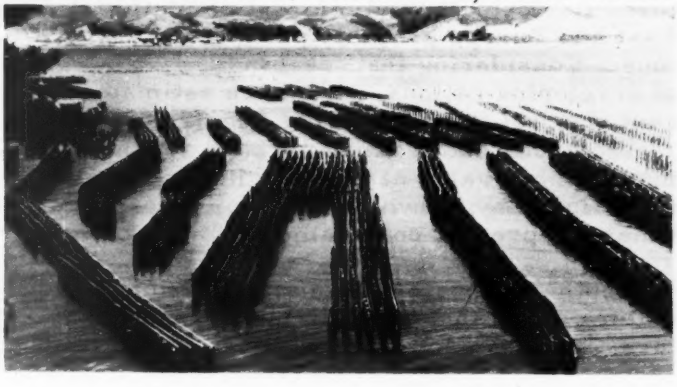


Left: Large mussel raft from which ropes hang in the sea, Spain.

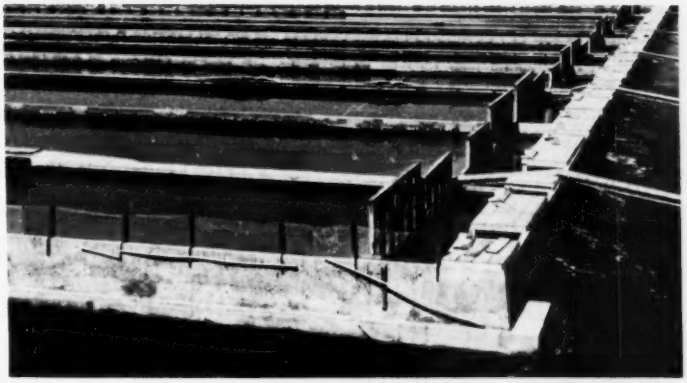
Right: Close-up of mussels being attached to rope with nylon thread (which dissolves in water), Spain.

Left: Mussels are collected on ropes (foreground) which are placed around poles (background), France. In a few months mussels will cover pole several inches deep. (Picture at low tide; area mostly under water.)

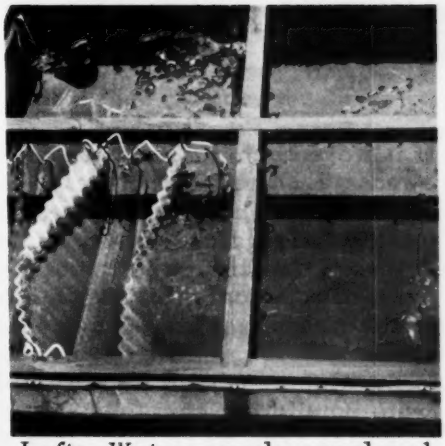
Right: Culture of porphyra (seaweed) on nets of palm or synthetic fiber, Japan.
(Photos: National Council on Marine Resources and Engineering Development)



Right: Running water ponds for adult shrimp, Japan.



Right: Young abalone in rearing tanks are collected and fed with plastic sheets on which a film of plankton has been attached, Japan.



Left: Water supply canal and dikes around milkfish ponds, Philippines.

Right: Harvesting milkfish with gillnet, Philippines. (Photos: National Council on Marine Resources and Engineering Development)

scale; FAO plans to promote the compilation of these data. A few rough estimates in Southeast Asia may be useful as an example of this kind of possible expansion:

Table 2: Present Status of Bangos (Milkfish) Pond Fishery in Southeast Asia

	Total Area of Ponds (hectares)	Total Production (tons)	Average kg/ha annum	Swamplands Available for Development (hectares)
Philippines	135,000	63,000	500	500,000
Indonesia	190,000	75,000	400	6,000,000
Taiwan	18,000	35,000	2,000	10,000
Total	343,000	173,000		6,510,000

If it were technically and economically possible to utilize the entire swamp area and bring the ponds established there to a level of production intermediate between the high- and low-yield levels, e.g., to 1,000 kilograms per hectare per year, the resulting yield would be over 6 million metric tons of fish—a quantity far exceeding the present total catch of the U.S. and close to the present productions of the fishing giants, Japan and the Soviet Union. Projections such as the above are dangerous because there are bound to be obstacles to development with the swamplands insufficiently surveyed and far from population centers. Nevertheless, even if only a portion of the potential area were developed but managed for highest rather than medium yields, a manifold increase over the present regional fish supply would be attained.

New Frontiers

In appraising the possible expansion of aquaculture one should also take into consideration some of the possibilities now intimated by pilot projects. The recent development of hatchery-rearing techniques for a variety of invertebrates (several species of mollusks, freshwater and marine shrimp) has opened up new opportunities for aquaculture in many parts of the world where estuaries and coastal lands suitable for pond construction abound and where the major constraint is the lack of organisms. The most immediate expansion of aquaculture in developing countries can be achieved by combining modern hatchery production with current local practices of low to moderate intensity of cultivation. As the cultivation techniques improve, however, increasing yields can be obtained from less area, a development now taking place in the advanced but land-poor countries.

Trout production depends on the availability of cheap feed and ample water of an even temperature around 17° C. The raising of 10,000 pounds of fish per cubic foot per second flow is considered possible, and the raising of 35 million plaice in an area of a square mile or two has been discussed, albeit speculatively.

Urban wastes can be put to use in aquaculture. Domestic human wastes can be used to the aquaculturist's advantage to feed algae (as in sewage ponds in Munich and Calcutta). The warming of effluent water from oil, coal or atomic power stations or other industrial plants having a need for cooling can be turned to a biological asset, inasmuch as aquatic cold blooded animals grow faster in warm than in cold water (as in experiments with plaice and sole in Scotland and with oyster culture in the U. S.).

Some areas for further investigation may be mentioned. When animals are brought into captivity they experience a decrease in environmental stimuli while they are, at the same time, subjected to some new ones for which they were not "programed" by evolution, so their reproduction is frequently impaired. Often the males produce sperm, but the females will not release their eggs. A thorough knowledge of the animal's biology and ecology is necessary before their reproductive functions can be manipulated satisfactorily; in most cases of semi-intensively cultured species this knowledge does not exist. In the case of fresh and brackish water fish the most important technique is hypophysation, the injection or implantation of pituitary gland material from the same or related species. Extension of this work to more species, e.g., the milkfish and some truly marine ones, will clearly be fruitful.

Genetic selection and breeding of desired varieties is presently possible only with aquatic organisms which propagate under controlled conditions and whose larvae or young are easy to raise. Some selective breeding has been attempted with oysters and shrimp, but only carp and trout have been developed into new varieties on a commercial scale. Selective breeding is now in progress with Tilapia (Malaysia) and may soon be possible with mullet. But not much is known about basic fish genetics, while the genetics of mollusks, crustaceans, and certainly of marine algae, is a virgin field.

Through the use of fertilizers, tilling and other practices, it is possible to enhance the yields of waters, but the amount of basic information on the interaction of pond, sea, lake or river bottom with the overlying water is slight. Practically nothing is known of the basic chemical processes that are altered or influenced when one fertilizes brackish waters. It is well recognized that some microscopic algae are readily used as food, others are useless "weed" species, while some are toxic or actually lethal. Plant physiologists

recognize that these organisms have different nutritional requirements, ecological preferences, and tolerances, but no efforts have yet been made to develop fertilization formulae or practices which would select for the beneficial forms and discourage those that are useless or harmful to the cultured animals. Their natural diets are in many cases but incompletely known, and the digestive physiology of invertebrates and herbivorous fish has hardly been investigated. Empirically-derived pond culture practices are often carried out with little or no understanding of what the animals in culture are eating.

Both the possible new techniques and the best uses of those already proved will require extensive research; basic and adaptive efforts are both needed. But current pilot projects and other indicators strongly imply that the results of such research, measured in the volume of nutrition from sources which would be added to those now available, could be very large indeed.

[Excerpted from "The Status and Potential of Aquaculture," Part I, a report prepared under the auspices of the American Institute of Biological Sciences for the National Council on Marine Resources and Engineering Development, Executive Office of the President, Washington, D. C., May 1968, pp. 2-32.]

IMPACT OF THE GREEN REVOLUTION

HIGH-YIELDING RICE BEING HARVESTED, MADAGASCAR.
(PHOTO: FOOD AND AGRICULTURE ORGANIZATION
OF THE UNITED NATIONS.)

The Green Revolution: Cornucopia or Pandora's Box?

Clifton R. Wharton, Jr.

[Along with their nutritional contributions, high-yielding wheat and rice seeds present numerous problems and potential dangers. With sufficient forethought and remedial action, however, the problems should be manageable.]

The rapid expansion of certain food grains in the developing world is being widely heralded as the "Green Revolution." Some observers now believe that the race between food and population is over, that the new agricultural technology constitutes a cornucopia for the developing world. Others see this development as opening a Pandora's box; its very success will produce a number of new problems which are far more subtle and difficult than those faced during the development of the new technology. It is important to give careful attention and critical analysis to both interpretations.

Major technological breakthroughs in food production are believed to have lifted the spectre of famine in the immediate future. Startling developments have been accomplished in wheat, rice and corn—the major food staples of the developing world. Overnight, the image of agriculture in the developing countries has changed from that of an economic backwater to that of a major potential contributor to overall development. The new varieties are rapidly spreading; a recent estimate of the U. S. Department of Agriculture is that in Asia alone the acreage planted with these new high-yield varieties rose from 200 acres in 1964/65 to 20 million in 1967/68.

Dr. Wharton is Vice President, The Agricultural Development Council, Inc., New York.

It will be no easy task to achieve the potential increased production offered by the new technology when it involves millions upon millions of diverse farms and scattered farmers. If the increased production is in fact obtained, this will automatically produce a whole new set of second-generation problems which must be faced if development is to be sustained and accelerated. Therefore, two considerations need to be borne in mind: first, there is reason to believe that the further spread of new varieties will not be as fast as early successes might suggest. Second, the new problems arising out of the spread of the new technology, whatever its speed, need to be foreseen and acted upon now.

The reasons for believing that the new technology will not in fact spread nearly as widely or as rapidly as supposed and predicted include, first, the fact that the availability of irrigated land imposes at least a short-run limit to the spread of the new high-yield varieties. Most of these require irrigation and careful water control throughout the growing cycle. The speed with which additional land can be converted to the new technology depends on the rapidity with which new irrigation facilities can be constructed. Large-scale irrigation projects can seriously strain the investment capacity of developing nations. Further, significant additional costs are involved in converting existing irrigation systems to the requirements of modern agriculture. Many of the old gravity irrigation systems were not designed to provide the sophisticated water controls demanded by the new varieties—e.g., each plot must be controlled separately throughout the growing season.

Second, there are doubts about the ability of existing markets to handle the increased product. Storage facilities and transport are inadequate. Crop grading is often deficient. The marketing system must be expanded to handle a larger output. Fertilizers, pesticides and insecticides must be available in the right quantities, at the right times, and in the right places. Given the inadequacy of the agricultural infrastructure, the need to expand and modernize marketing systems is likely to reduce the pace of the Revolution.

Because many of the new varieties, especially rice, do not appeal to the tastes of most consumers, it is difficult to calculate the size of the market. Some argue that until newer varieties which are closer to popular tastes are developed, the market will be limited.

Third, the adoption of the new technology is likely to be much slower where the crop is a basic food staple, grown by a farmer for family consumption. Such farmers are understandably reluctant to experiment with the very survival of their families. Peasant producers are far more numerous in the developing world than are commercial farmers, and the task of converting them to a more modern

technology is considerably more difficult. So far, spectacular results have been achieve primarily among the relatively large commercial farmers. Some semi-subsistence farmers have begun to grow the new varieties, but the rate at which they adopt them may be slower.

Fourth, farmers must learn new farming skills and expertise. The new agronomic requirements are quite different from traditional methods as regards planting dates and planting depths; fertilizer rates and timing; insecticide, pesticide and fungicide applications; watering and many others. Unless appropriate extension measures are taken to educate farmers in these new farming complexities the higher yields will not be obtained.

Fifth, many of the new varieties are non-photosensitive, and the shorter term will allow two or three crops per year instead of one. Multiple cropping is good, but there may be difficulties if the new harvest comes during the wet season without provision for mechanical drying of the crop to replace the traditional sun drying. There may also be resistance if the new harvest pattern conflicts with religious or traditional holidays which have grown up around the customary agricultural cycles.

Sixth, failure to make significant institutional reforms may well be a handicap. There is evidence in several Latin American countries that a failure to make needed changes in policies now detrimental to agriculture, or a reluctance to effectuate the institutional reforms required to give real economic incentives to small farmers and tenants, has been primarily responsible for the very slow spread of Mexico's success with new varieties of wheat and corn to its neighbors to the south.

From all this one may deduce from the above that the early adopters of the new technology will be in regions which are already the more advanced, literate, responsive and progressive and which have better soil, better water management, closer access to roads and markets—in sum, the wealthier, more modern farmers. When they do adopt it, the doubling and trebling of yields mean a corresponding increase in their incomes. One indication of this is the large number of new private farm-management consultant firms in the Philippines which are advising large landlords on the use of the new seed varieties and making handsome profits out of their share of the increased output.

As a result of different rates in the diffusion of the new technology, the richer farmers will become richer. The more progressive farmers may capture food markets previously served by the smaller semi-subsistence producer. In India, only 20 percent of the total

area planted to wheat in 1967/68 consisted of the new dwarf wheats, but they contributed 34 percent of the total production. Such a development could well lead to a net reduction in the income of the smaller, poorer and less venturesome farmers. This raises massive problems of welfare and equity. If only a small fraction of the rural population moves into the twentieth century while the bulk remains behind, the situation can be highly explosive.

The slowness with which a food-deficit psychology dies has an important consequence in terms of government pricing policies. The shock which quantum jumps in food production may have on domestic prices has not been sufficiently appreciated. The downward pressure on prices, especially where transport is deficient and storage is inadequate, may in fact be so severe as to have a disincentive effect upon producers. Unless adequate attention is given to developing a sound pricing policy to prevent excessive dampening of incentives, the spread of the new technology may in fact be cut short before any "takeoff" has occurred.

It has been amply demonstrated throughout the world that peasant and subsistence farmers are responsive to favorable prices, provided the return is real and they receive the benefit. Thus, if the full potential offered by the new technology is to be realized, every effort must be made to insure that there is in fact a significant return to the producer.

The goals of increased food production are frequently couched in terms of some desirable, minimal standards of nutrition; but these can be attained only by individuals who have the income to purchase the better diet. Effective demand for food depends upon both the income of the demanders and the price of the food. If the increased production leads to lower costs and prices, then consumers will be able to increase their food purchases and hopefully to raise their levels of nutrition. Equally important is the need to increase incomes so that the greater production entering the market can be purchased. Unless the higher levels of effective demand materialize, the prospect will be market gluts, price depression and, in certain cases, shifts by the farmers away from the higher-yielding varieties. Hence, every effort must be made both to reduce the unit costs of the increased food output and to augment the incomes of consumers who purchase food; otherwise, the second bowl of rice will not be bought—despite the technical feasibility of producing it.

Some experts argue that the new technology's stimulus to production and income cannot be stemmed. In several countries the demand for the new seeds is outstripping the available supplies, and black markets are developing in seeds and fertilizer.

If the new varieties continue to live up to expectations and spread rapidly and widely, the increased production will in turn lead to a new set of difficulties. Large tracts planted in one of the new varieties may be susceptible to disease and infestation which could cause massive losses. Heretofore, reliance upon seed selected by individual farmers meant that neighboring farms growing the same crop usually planted two or more different varieties or strains. This heterogeneity provided a built-in protection against widespread plant diseases, since no all varieties are equally susceptible. But where a single variety is introduced, covering large contiguous areas, the dangers of pathologic susceptibility are multiplied. For example, the new wheat introduced from Mexico into the Indo-Gangetic belt in India and Pakistan has involved a small range of genotypes—and the same has been true in Iran, Turkey and certain Middle Eastern countries. Any change in the spectrum of races of wheat rust in any of these countries could threaten the wheat crop on a massive scale, since it would involve the entire area.

Two steps are necessary to avoid these dangers: first, a diversified breeding program which can continually produce new varieties; second, an able and well-organized plant protection service which can quickly identify dangerous outbreaks and initiate prompt steps to combat them. Both activities must rely primarily upon national organizations and demand a skilled, well-trained staff. Some nations have recognized these dangers and are taking steps to meet them, but others still have not been made sufficiently aware. Aid givers who are responsible for promoting the new varieties bear an equal responsibility to promote indigenous research and plant protection services. The outbreak of any major disease which wipes out the harvest of thousands of farmers is far more likely to be blamed on the producers and spreaders of the miracle seed than on Fate.

Any government or foreign-aid agency which distributes the "miracle" seed but fails to provide the insecticide and fertilizer in the appropriate quantities when and where needed is courting political disaster; unless these inputs are available and used, some local, traditional varieties will outyield the new ones. It is vitally important to expand the entire complex of services and industries required to achieve the higher production. A seed industry, agricultural chemical plants, processing and storage firms, factories producing hand sprayers, dusters, water pumps and engines—these are just a few of the agriculturally related industries which must develop if the Revolution is to take hold.

The skills and the capital needed cannot be provided solely by the public sector. Private capital must also be utilized to provide a new, more dynamic pattern of distribution. In a few countries the spread of the new technologies has already forced an abrupt

departure from the previous practice of having government agencies serve as the major or sole distributor of the required inputs. In the Philippines, for example, ESSO has become a major distributor of fertilizer and agricultural chemicals. In India, the International Minerals and Chemicals Corporation, with the Standard Oil Company of California, built a fertilizer plant with a yearly capacity of 365,000 tons; the U.S. firms provide the management but control is held by an Indian firm. Storage silos, seed multiplication firms and even integrated farm-to-retail firms are just a few of the activities where private resources are being harnessed to the Green Revolution.

Equally important are the increased farm services required, particularly agricultural credit. The International Rice Research Institute estimated that whereas the total cash costs of production for the average Filipino rice farmer using traditional methods and varieties is about $20 per hectare, the cost rises to $220 when the new, high-hielding IR-8 is grown. Although the yield may increase threefold, the farmer must have access to substantially greater credit to finance his operations—especially the poorer farmers with low cash reserves. The village moneylender and merchant will not be adequate unless they in turn have access to additional funds. Indeed, the Green Revolution must be accompanied both by an increase in the amount of credit available and by the expansion and modernization of credit institutions and mechanisms. Tapping the capital markets in the modern urban sector must be encouraged, and ways must be found at the village level to mobilize local capital, especially the increased savings which are possible from higher farm incomes. The Green Revolution will generate increased cash which, if properly marshalled, can contribute to capital formation and agricultural progress.

Much more attention must be devoted to marketing the increased output. Where there has been semi-subsistence agriculture, the impact of the new technology upon the marketed product is even greater than on total production. If the crop is a food staple and if the peasant farm family traditionally consumes some 70 to 80 percent of its total product each year, a doubling of output does not lead to a doubling in the amount retained for family consumption. Some modest increase in consumption is likely, but the bulk of the increased production will enter the market.

The impact of this explosive increase upon the traditional marketing network and storage capacity can be calamitous. The case of India is illustrative. During the past crop year, India experienced a marvelous increase in food grain production, but the marketing network and storage facilities were not prepared to cope with it. The result could be seen in the mountains of food grain stored in schools

and in the open air. The food-deficit psychology which underlies the failure of planners and policymakers to anticipate these results is not limited to the developing nations; aid givers were equally surprised.

One of the major avowed aims of most nations which are eagerly promoting the Green Revolution is to achieve self-sufficiency in food production. The Philippines already claims to have become self-sufficient; Malaysia predicts that she will be self-sufficient by 1971; Indonesia by 1973. Some believe that these target dates are overly optimistic. But if the rice-deficit nations eventually become self-sufficient by successfully adopting the new technology, what will happen to the rice-surplus nations like Burma and Thailand whose economies are heavily dependent upon rice export? To whom will they sell their rice? Whether or not one agrees with the goal of self-sufficiency for the former nations, the policies have been adopted and will be pursued. Many developing nations spend some 30 percent of their foreign exchange on food imports and wish to eliminate this drain as well as the irritation of chronic deficits in domestic production. Unless the exporting nations take immediate stock of their prospects and seek to diversify their agriculture, the impact of such trade distortions could have major consequences for their economies and pace of development.

Are these technological developments a "once-and-for-all" phenomenon? How likely is it that new technological improvement will continue to be made? Much will depend upon whether or not the necessary manpower is trained in each country to provide a continuing human resource which can produce a constant stream of new technology. The manpower trained in the Rockefeller Foundation's Mexican program has been a greater contribution, in my view, than the new varieties. The target should be not a new technology but ever-new technology, and this requires skilled manpower.

There are several broader issues which can be raised only as questions:

To what extent will the diffusion of the new technology accentuate the displacement of rural people and heighten the pace of migration to the cities? If higher yields per acre, multiple cropping plus mechanization, force surplus manpower out of agriculture, what are the prospects for increased employment in industry and services to absorb this manpower?

What will be the political significance of these changes if successful adoption of the new technology leads to an economically invigorated and strengthened rural population—almost invariably a large

majority in developing nations? Will rural-based political parties and movements emerge to alter the recent dominance of urban centers?

What will be the global effect of a food explosion in the tropical and subtropical world? Will such developments lead to an improved reallocation of productive specialization among the developed and developing world?

One final danger lies in assuming that there is no longer an urgent need for measures to reduce rates of population growth. Quite the contrary. While the new developments are a splendid gift of time to allow a holding operation, effective population measures continue to be essential. Whether one assumes a growth rate of 2.5 or 3 percent, the inexorable fact is that, give or take a few years, the population of the developing world will double in about 25 years.

To speak of the possible consequences and problems associated with the next phase of the Green Revolution should not be misinterpreted as a plea for the suppression of the Revolution. On the contrary, I would strongly argue that the problems are a measure of what great opportunities exist for breaking the centuries-old chains of peasant poverty. Now is the time to place this Revolution in its long-range perspective, and to engage in contingency planning so that we may respond flexibly and quickly as it proceeds.

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Probable Limits on New Grain Varieties in Asia

Joseph W. Willett

[The most important limitation to the spread of new varieties is the supply of suitably irrigated land. While these new varieties may have added 10-20 percent to the grain supplies of Asian countries, their contributions should not be exaggerated.]

The rapidity of the spread of the new grain varieties in the last few years in some areas has been extraordinary. The rapid spread has been built on a well-established institutional base (as in India's Intensive Agricultural Districts Program) or vigorous government action (as in Turkey), or both. The availability of a combination or "package" of inputs which usually have been subsidized and provided at incentive prices in relation to the farmer's price of grain has greatly stimulated farmer acceptance of the programs.

The improved wheat varieties spread rapidly on irrigated acreage in Mexico from 1949 to 1956. At present the improved seed is used on nearly all of Mexico's wheat area of which nearly 90 percent is irrigated and more than two thirds is fertilized. The Mexican wheats were introduced into Pakistan and India in small quantities during 1963/64. In 1966 India made a large purchase of seed from Mexico; in 1967 Pakistan made an even larger purchase, and Turkey began its program. Comparably large plantings of new rice seeds began in India in 1966/67, the Philippines in 1967/68, and West Pakistan in 1968/69.

Mr. Willett is Deputy Director, Foreign Regional Analysis Division, Economic Research Service, U. S. Department of Agriculture, Washington, D. C.

Despite their rapid spread, the new varieties were not planted on a large enough share of the grain acreage in Asia in 1967/68 to have had a major impact on production in the less developed countries as a whole. Less than 3 percent of the rice area in South and Southeast Asia was planted to new varieties in 1967/68; about 11 percent of the wheat area in West and South Asia was planted to new varieties in that year. The share of the total wheat area seeded to new varieties in 1967/68 was insignificant in Turkey and Afghanistan but amounted to about 12 percent in Pakistan and nearly 20 percent in India. In the 1968/69 crop season the new rice varieties were planted on some 13 million acres, nearly 7 percent of the total rice land in South and Southeast Asia. The new wheat varieties were scheduled for planting on 14-15 million acres or about 16 percent of the total wheat area in West and South Asia.

Production Impact

Reliable estimates of the impact of the new varieties on grain availability in Asia would require comparing yields of new and traditional varieties by region, while accounting for the influence of other factors such as weather, acreage changes, fertilizer, prices, credit availability, irrigation, availability of extension services, etc.

Weather. The new varieties were first planted on substantial acreages in Asia in 1967/68, a year of generally good weather in the region. In India and Pakistan especially, the large increases in area planted to new varieties in that year coincided with excellent weather following two years of drought. (It has been estimated that high-yielding varieties added about 6 percent to India's total grain production in 1967/68 and that good weather added about 7 percent.)

Acreage changes. The total acreages planted to both new and traditional varieties increased as follows in 1967/68: wheat in India, 10 percent; wheat in Pakistan, almost 10 percent (irrigated wheat acreage expanded 20 percent); rice in Pakistan, almost 10 percent. Rice acreage remained unchanged in India and (as estimated) in the Philippines. Turkey's wheat area did not change.

There have been frequent reports that the best lands were planted with the new varieties. In Turkey, Mexican wheat was distributed in "areas of low latitude and high rainfall." In the Philippines, IR-8 was planted on the "most productive rice growing area." All of the new wheat varieties used in Pakistan were planted on irrigated land, and this apparently was also the case in India. In India the Mexican wheats are said to have been planted by better-than-average farmers.

Fertilizer consumption increased 50 percent in India and 30 percent in Pakistan in 1967/68. It is reasonable to assume that much of that increment in fertilizer was used on new varieties, but detailed information is not available.

Farmers' yield experiences with the new grain varieties have varied greatly. In India, for example, 1967/68 yields of the new wheats ranged from less than 2,000 to more than 6,000 lbs. per acre. Table 1 assembles some results from a number of experiments and farm performance surveys (in each comparison the last indicated is a traditional variety).

Table 1: Data on Average Yield Advantages of New Varieties

Variety	Yield (Metric Tons/ Hectare)	Remarks
Rice:		
Dwarf Indica	4.1	Both at 100 kilograms of nitrogen per hectare, uniform variety trials, kharif 1966, India.
Local Indica	3.2	
IR-8	5.1	All at optimum marginal benefit-cost fertilizer application, experimental, wet season 1966 and 1967, International Rice Research Institute, Los Baños, the Philippines.
IR-5	4.9	
Peta	2.7	
IR-8	6.2	Same conditions as above, Maligaya, the Philippines.
Peta	4.2	
IR-8	6.8	Same conditions as above except dry season, Maligaya, the Philippines.
IR-5	7.1	
Peta	4.0	
Wheat:		
Sonora Wheat 63	n.a.	Sonora 63 has a 30-35 percent yield advantage over local varieties, both at optimum levels of fertilization, based on experimental results in India.
Local Varieties	n.a.	
Mexican Wheat	4.7	The 1966/67 crop in Ludhiana District, Punjab State, India; Mexican wheat was planted on only 11 percent of the wheat area in the district, probably by the best farmers on the best land.
Indian Wheat	2.4	

Table 1 Continued:

Variety	Yield (MT/ Ha.)	Remarks
Lerma Rojo Wheat 64 A	3.7-5.0	Tests and demonstrations, 1966/67-1967/68, India.
Local Varieties	1.9-2.5	
Semi-dwarf Wheat	2.8	Both varieties grown on same farm, India.
Local Varieties	1.6	
New Varieties	1.8	Both irrigated, West Pakistan
Local Varieties	1.0	

In 1968/69 the new rice varieties occupied about 7 percent of the total rice area in South and Southeast Asia. Average rice yields in the region before the introduction of the new varieties were about 1.6 metric tons per hectare. Table 1 suggests that yields from traditional seeds under some of the better conditions may have been twice that, so that the best lands in that 7 percent of the area may have already been producing 14 percent of the rice. A doubling of these yields (100 percent yield advantage) by use of new varieties, would add another 14 percent to the total output. On the other hand, a 30 percent yield advantage would add only 4.2 percent (30 percent x 14 percent). A midpoint of this range would be about 9 percent, a very rough estimate of the addition to production of rice.

About 16 percent of the wheat area in the less developed Asian countries was scheduled to be planted to new varieties in 1968/69. Wheat yields in the region averaged about 1 metric ton per hectare before the introduction of the new varieties. Again, Table 1 suggests that yields from traditional seeds under the better conditions may have been twice that. Using the procedure followed above for rice, a rough estimate is that the new varieties would add from about 9.6 to 32 percent to wheat production in the region in 1968/69. The midpoint of this range is around 20 percent.

This paper includes no forecast of additional increases of production from the new varieties. Expansion to poorer lands will tend to lower yields; but experience and adaptive research should tend to raise them. Farmer prices for grains, for competing products and for inputs will affect both acreage and yields, but there is little information available for making estimates.

Multiple-cropping. The above estimates do not include the contribution from multiple-cropping. An important characteristic of the new varieties is their shorter growing period and consequent potential for multiple-cropping. However, even with good irrigation systems, multiple-cropping requires a high level of managerial skill to coordinate a series of complex activities, and it is unlikely that it will spread quickly to areas where it is not already practiced—though Malaysia might prove to be an exception. Multiple-cropping also creates new problems: for example, in Thailand in an area where year-around cropping has expanded, the presence of lush young plants throughout the year has not permitted the normal insect depletion common when the land was barren six months annually.

According to a recent survey, the potential land for double-cropping of rice under existing irrigation is less than 10 percent of the total rice area in South and Southeast Asia, where the present double-cropped area amounts to 5 percent of the land in rice. As irrigation systems are improved and extended and farmers gain experience, the area double-cropped could be expanded. In India, about 13 percent (46 million acres) of the net area sown to all crops (342 million acres) was double-cropped in 1967/68. However, the bulk of the double-cropped area (31 million acres) is unirrigated and thus unsuitable for high-yielding grain varieties. It is expected that the irrigated and double-cropped area will increase by only about 5 million acres—less than 2 percent of the new sown area—by 1969/70.

Limitations to Spread of New Seeds

A shortage of suitable irrigation appears to be the most important input limitation to the spread of the new varieties. Unless water can be carefully controlled, the advantage of new varieties decreases rapidly. Many of the irrigation systems in South and Southeast Asia are not of the proper type for full realization of the potential of the new varieties. In many existing systems the water flows by gravity from one field to the next; individual farmers can't control water flow and their fertilizers and plant protection chemicals are carried off in the flowing water. Sometimes it is not possible to let the upper fields dry out in time for the harvest of the new varieties, so the problem of wet grain at harvest is accentuated.

In much of Southeast Asia the broad valleys will require large dams and long irrigation systems if additional irrigation facilities are to be built. Such systems cannot be built by local enterprise alone; government action to supply the initiative, capital and expertise may be required. New forms of cooperative organization may be necessary to coordinate the use of the water.

In India and Pakistan irrigation by pumps has grown rapidly. In West Pakistan nearly 32,000 tube wells were installed by private enterprise in 5 years. In many areas of Asia there probably are large underground water resources which could be developed effectively. However, surveys and careful attention to water management will be necessary.

In India, the 22.6 million acres planned for high-yielding varieties in 1968/69 represents 27 percent of the total irrigated grain area and a very much higher, although undetermined, percent of the land with reliable water control during the dry season. Inadequacy of the irrigation system is limiting the spread of the new varieties in India; in the plans for 1969/70, the increase in the planned acreage under high-yielding varieties is almost equal to the planned increases in irrigated grain acreage. The irrigated area projected for traditional varieties, on the other hand, remains very large and virtually stable; this suggests that water control on this area is not sufficiently reliable to risk the high cash costs of fertilizer and insecticides required by the new varieties. Shortage of neither the new varieties of seed nor of fertilizer are expected.

West Pakistan has a good environment for the new wheat varieties—adequate irrigation over a large area, low rainfall, high solar energy, and few insect problems. Long-standing problems of poor drainage and salinity are now being attacked. About 20 percent of West Pakistan's wheat land was planted to new varieties in the fall of 1968, and further expansion is possible. However, the potential for new varieties of rice in Pakistan is much more limited than for wheat. In East Pakistan, where 90 percent of Pakistan's rice is grown, the regular uncontrolled flooding of most of the producing areas lessens the value of the new short-stemmed varieties in the main spring and summer seasons. In addition, insect and disease problems complicate the growing of new varieties in East Pakistan. West Pakistan, which has better growing conditions, produces basmati rice, an extra-long-grain variety. A significant share of this rice is exported at premium prices. The government has increased the minimum purchase price to deter basmati producers from shifting to other varieties, but exports of basmati rice have declined rapidly in the last few years.

The main obstacles to a rapid increase in the production of high-yielding rice in the Philippines appear to be the lack of good irrigation, a shortage of rice-drying facilities, and problems of consumer acceptability. The new varieties mature early during the latter part of the wet season and, in 1967/68, many farmers had to sell new type rice wet in the fields at a 20 percent discount because of a shortage of drying facilities and the inferior quality of the rice.

Lack of water control (rather than absence of irrigation per se), along with the inferior taste quality of the new rice varieties relative to export grades, are the main deterrents to their spread in Thailand and Burma. For example, large areas of good land in Thailand are irrigated by annual flooding to such a depth that short-stemmed rice is a disadvantage. A shortage of fertilizer at the farm level is a handicap in Burma and Indonesia.

In Turkey, Mexican wheat seems to be adapted to the warmer coastal areas. The Turkish program for expansion of the acreage of this wheat developed very rapidly with little preparation. In 1968/69 Mexican wheat was planted on about 7 percent of the total wheat land, and within a few years it will probably be grown on much of the southern and western coastal wheat lands, i.e., on about 15 percent of Turkey's total wheat acreage. New dry-land wheat varieties may hold promise for increased yields in the more arid interior wheat fields of Turkey. Varieties are available which, under the proper conditions, greatly increase production without the necessity of irrigation. However, efficient dry-land wheat farming is complicated and requires mechanization for proper tillage. The stubble-mulch system, which has been developed in the U.S. Great Plains, requires heavy equipment for subsurface plowing and deep planting. For such methods to be introduced in areas of peasant farming will require the development of institutions to obtain and coordinate the use of heavy equipment.

[Excerpted from "The Impact of New Varieties of Grain in Asia," Spring Review of the New Cereal Varieties. Washington (D.C.): U.S. Agency for International Development, 13-15 May 1969, pp. 8-22. Unpublished report.]

After Self-Sufficiency

Lester R. Brown

[If current production trends continue, several developing countries will achieve self-sufficiency in food grains and begin confronting surpluses for which they will not easily find export markets. Diversification is therefore desirable, into production of oilseeds, fruits and vegetables, or into feed grains and the poultry or livestock industry.]

Failure to achieve food production targets was common in many developing countries during the 1960s; exceptions, such as Mexico and Taiwan, were few. Between 1967 and 1969, however, the situation changed markedly with over-achievement of targets in food production becoming quite common. Between 1966 and 1973, developing countries containing nearly a billion people are expected to achieve self-sufficiency.

Mexico achieved cereal self-sufficiency in 1957, following dissemination of the high-yielding wheats developed by Rockefeller Foundation scientists. Kenya achieved self-sufficiency in corn production in 1966; new corn hybrids now in use in Kenya will nearly double yields of the more traditional varieties. The Philippines, with its record-breaking rice harvest in 1968/69, is now producing substantially more rice than it can consume after 50 years of dependence on imports. A one third increase over the past two years in production of wheat, Iran's staple food, has taken it beyond self-sufficiency and into the export market.

Mr. Brown, formerly Administrator of the International Agricultural Development Service, U.S. Department of Agriculture, is Senior Research Fellow, Overseas Development Council, Washington, D.C.

In 1968 Pakistan became a net exporter of rice; West Pakistan's combined surpluses of wheat and rice in 1969 are estimated at almost a million tons, nearly enough to fill the deficit in East Pakistan. Gains in the Turkish wheat crop attributable to the use of high-yielding Mexican wheat totaled 340,000 tons for the crop harvested in 1968 and the acreage in the Mexican wheats is expanding. In India an extension of the rising production trend of the past few years would indicate a cereal output of 120 million tons by 1974, which means self-sufficiency in 1972. Indonesia, now rapidly moving forward in production of both corn and rice, is planning to export corn in significant quantities in 1969 and hopes to eliminate rice imports within the next few years, as do Ceylon and Malaysia.

Table 1: Self-Sufficiency in Food Staples

	Wheat		Rice		Corn	
Achieved	Mexico	1957	Philippines	1968	Kenya	1966
	Iran	1967	Pakistan	1968		
	Afghanistan	1969				
Expected	Turkey	1970	India	1972		
	Pakistan	1970	Malaysia	1973		
	India	1972	Ceylon	1973		
	Israel	1973	Indonesia	1973		

Self-sufficiency brings with it new opportunities and problems, and results in a characteristic series of actions—a self-sufficiency syndrome. The production momentum required to become self-sufficient in food often goes beyond domestic need into surpluses, and countries try to export the surplus. More often than not they are unsuccessful because they are not competitive in price or produce the wrong quality for the market. As storage facilities overflow and prices drop, the temptation is to shift land into non-cereal crops; this, too, usually has limited potential. Countries may expand poultry and livestock production as a way to absorb excess grains. Hopefully, the countries now approaching self-sufficiency can learn from those who reached it earlier and avoid some of their miscalculations; if not, consequences can be more serious than in the past when surpluses evolved more slowly.

Exportable Surpluses

Rapid gains in production of wheat, rice or feed grains are usually much easier when a country is a deficit producer. Under these

circumstances, it can set domestic prices independently of world prices, focusing on the price level needed to provide the necessary intentives. Once a country reaches self-sufficiency, however, and begins to produce surpluses, it must then make sure that its prices are competitive or below world prices, or be prepared to subsidize exports.

The number of developing countries with exportable surpluses of grain is expanding, and some are gaining a foothold in world markets. An outstanding example of this is Thailand with corn; now ranked among the top five corn exporters, it exported more corn than rice in 1968. Mexico has in recent years exported small quantities of four major cereals—wheat, corn, rice and sorghum. Iran exported wheat in both 1967 and in 1968, and its potential should increase substantially further. Brazil, a marginal exporter of both corn and rice in recent years, increased its exports of corn to 1.2 million tons in 1968, double the previous record.

Other countries, however, have not found reliable external markets for reasons for quality or price. As former importing countries reach self-sufficiency, the export markets for other countries are thereby reduced. Exportable surpluses may well grow faster than import demand if present trends continue, and the competition will become even stiffer. So a number of countries must then either develop a livestock industry to utilize the excess grain or diversify agriculture, shifting grain-producing resources into oilseeds such as soybeans or peanuts, into fruits, vegetables or other crops.

The Diversification Spinoff

Agricultural diversification, the oft-stated goal of economic planners in developing countries, has not proceeded very rapidly except in a few countries. But several factors associated with the present breakthrough are generating more diverse patterns of demand. When incomes are very low, they are used largely to purchase starchy food staples. Only as incomes rise above the subsistence level does money become available for the purchase of animal protein foods such as meat, milk and eggs, and fruits and vegetables. In Thailand, for example, an economic growth rate ranging from 5 to 8 percent yearly in recent years is generating sharp increases in the demand for fresh vegetables, production of which has increased an estimated 50 percent within the past few years.

Adoption of the new technologies by subsistence farmers requires that they enter the marketplace. In so doing, they become more sensitive to the demands of the marketplace, planning their production in response to factors going well beyond immediate family needs. As countries (like family farms) reach self-sufficiency in

the production of food grains, resources will be freed up for other agricultural enterprises. This is especially true where the new seeds make possible expansion of multiple cropping, particularly in combination with short-season crops such as vegetables. The spread in multiple cropping and the diversification of agriculture are proceeding hand in hand.

Fruits and Vegetables

If the agricultural revolution in the developing countries is accompanied by a continuing liberalization of agricultural imports by the industrial countries, diversification in the tropical-subtropical countries should proceed at an unprecedented pace. The range of crops which can be produced in these regions is generally much broader than that which can be produced in the temperate zone countries. Their year-round growing conditions can complement nicely the production patterns of the northern temperate zone industrial countries, particularly during their winter season. Developing countries must maintain flexible production patterns, however, to take advantage of more efficient technologies, shifting prices and evolving market opportunities.

The liberalization of banana imports by Japan in 1963 created new banana export industries in nearby countries in East Asia. Taiwan's exports of bananas, totalling a few million dollars yearly in 1955, soared to $55 million in 1965, following the Japanese liberalization. The Philippines has developed a banana export operation which is expected to reach 3,500 tons of bananas a week, eventually earning $5 million of foreign exchange per year. Malaysia is also developing banana exports for the Japanese market. Several developing countries are now exporting more than $50 million worth of fruits and vegetables yearly; these include Turkey, Israel, Mexico, Taiwan, the Philippines and Chile. As air transport, e.g., the "jumbo jets," is more widely used, the possibilities for exporting high-value products, such as fresh strawberries and lettuce, will be greatly enhanced.

New highways are also linking areas of potential production with world markets. A classical example is the Friendship Highway in Thailand, linking Saraburi-Korat with Bangkok, which has opened a large new area for upland crop production. The paved roads starting from the Khyber Pass on the Pakistan-Afghanistan border, linking Pakistan with the Soviet Union and the Middle East, are opening an entirely new market for fruits and winter vegetables for Pakistan's farmers.

Taiwan and Mexico, the two developing countries with outstanding agricultural growth records over the past two decades, are

diversifying rapidly. Taiwan's agricultural exports in 1950 were confined largely to sugar, which accounted for four fifths of all exports; rice accounted for much of the remainder. By 1967 sugar accounted for only 7 percent of total exports and rice less than 6 percent. Banana exports reached 10 percent in 1967 and canned fruits and vegetables accounted for $84 million, consisting mainly of asparagus, canned mushrooms and pineapple. Taiwan's farm diversification is a dynamic, continuing process; potential export items now being considered for canning or freezing are bamboo shoots, water chestnuts, citrus fruits, and sweet potatoes.

Mexico's agriculture has diversified rapidly during the 1960s. After reaching self-sufficiency in wheat, the Mexican Government discovered that internal prices were well above world market prices and began shifting resources into the production of feed materials as a basis for expanding the grain-based poultry and livestock industries. Corn production increased from 6.4 million tons in 1963 to 9 million tons in 1968, sorghum from 400,000 tons to 2 million and soybeans even more rapidly, from 24,000 tons to 225,000 tons. Production of fruit and vegetables, largely for the United States during the off-season, also expanded rapidly. The production of strawberries, watermelons and cantaloupes all tripled in the five years up to 1968.

Pakistan is just beginning to diversify its agriculture, and its prospects seem quite good. Peanuts, a crop yielding both vegetable oil which Pakistan imports and oilmeal which is a valuable protein supplement for livestock feed, have increased from 70,000 acres in 1966 to 189,000 in 1968. The demand for fruits and vegetables within Pakistan is projected to double by 1980 from just over 5 million tons in 1965. Malaysia, already pressing forward in rice production, has initiated programs to expand corn and sorghum production. Exports of pineapple, increasing by 14 percent yearly during the sixties, have made Malaysia the world's fourth largest exporter.

Developing a Poultry-Livestock Industry

As the developed countries achieved self-sufficiency in the production of food grains, feed grains acquired a new and more important status; they were used as the basis for an improved and expanded livestock and poultry industry. With the developing countries moving into a similar situation, and with the demand for animal products soaring, there are excellent prospects that this pattern will become global. Some of the resources that are presently devoted to food grain production will be diverted to feed grains as yields of both increase and the domestic demands for the former are satisfied.

During the late 1960s production of livestock and poultry, particularly the latter, turned sharply upward in many developing countries. In the past livestock competed directly with man for the limited grain resources available. As increases in the available grain supply provide more than is needed for direct human consumption, pressure for developing grain-based poultry and livestock industries is increasing, especially when countries cannot find external markets for their cereal surpluses. During the 1970s, the production of poultry and livestock in the developing countries is likely to expand far more rapidly than the production of crops.

At present, consumption of poultry and livestock products is quite low in nearly all developing countries, often only a few pounds of meat per person per year—a small fraction of the 122 and 178 pounds consumed in Western Europe and the United States respectively. Within the poultry-livestock sector, the production of poultry, particularly broilers, will likely expand most rapidly. Modern broiler production technologies, developed in the United States since World War II, are now spreading in the less developed world. Only minor modifications are required in this technology for local conditions and resources. Developing countries can almost overnight take advantage of new developments in poultry nutrition, breeding, and flock management.

Poultry has several advantages over livestock for the poor countries. It usually costs less since the grain required to produce a pound of poultry is much less than with pork or beef. A well-managed broiler flock requires only 2.5 pounds of grain per pound of meat, whereas approximately 4 pounds of grain are required for one pound of pork and 7 pounds of grain for one pound of beef. Grain-fed beef (though not necessarily grass-fed beef) is often much more costly than poultry.

Another attraction of poultry is the short payout period. Chicks hatch in 21 days, and with modern management and feeding broilers are ready to market within 10 to 12 weeks, enabling investors to recoup their capital quickly. Moreover, chickens are small and can be consumed shortly after slaughter whereas storage and preservation problems arise with beef and pork. How rapidly poultry production grows in a given country depends partly on how rapidly the feed-mixing industry expands. The feed companies from the United States have often taken the lead in introducing the new technology; when adeopted by local farmers on a commercial scale it rapidly expands the market for commercially mixed feeds. The growth of hatcheries producing high-quality chicks will also encourage formation of a broiler industry; many leading U.S. hatcheries have already established their lines in a number of developing countries. The availability of poultry pharmaceuticals also influences the rate of

expansion of the commercial poultry industry. The introduction of modern broiler production technology often reduces the price of poultry from some 80 cents to about 40 cents per pound.

Colombia and Thailand have achieved dramatic advances in poultry production in recent years. The introduction of modern poultry technology in Colombia resulted in the doubling of poultry and egg production over the past decade. The number of chickens in Thailand is estimated to have doubled during the last half of the sixties. Egg production increased 20 percent in 1967 alone.

The dramatic gains in efficiency achieved in broiler production in the past two decades have far exceeded those with cattle or hogs. In developing countries where feed resources are relatively scarce, or in countries dependent on imports for most of their feed materials such as Japan, policies are increasingly designed to encourage the development of poultry industries, sometimes at the expense of livestock.

In addition, much more time is required to expand production of livestock than of poultry, partly because the life cycle is so much longer. In Latin America and parts of sub-Sahara Africa, where land is still relatively abundant, prospects are much better for the expansion of livestock than in the more densely populated North African, Middle Eastern and Asian countries. Both rising incomes within the developing countries and expanding export prospects are stimulating the expansion of livestock herds. Efforts to convert the livestock potential of Latin America and sub-Sahara Africa into exports are being assisted by substantial loans from the International Bank for Reconstruction and Development, and the Inter-American Development Bank. Indicative of the planned expansion in cattle production in the developing countries is the sharp upswing in export of U. S. breeding cattle particularly to Latin America from $11.6 million in 1960 to $23.8 million in 1967.

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Farmer Experience with the New Rice Varieties

Randolph Barker

[From the second year's use of IR-8 rice in the Philippines a seasonal pattern emerges, with both IR-8 and local seeds in use. The spread of new varieties will shift the comparative advantages in rice production among Asian countries.]

Adoption Pattern in the Philippines

A survey has been conducted annually on 155 farms in Laguna Province during the past three years to observe the changes taking place with the new high-yielding rice varieties. Although 90 percent of the farm operators are tenants, the level of management and resource input is higher than would be found in many regions. The province has relatively good irrigation facilities, and provincial yields are normally well above the national average. Information on the pattern of adoption of new varieties is presented in Table 1 and comparisons are made between the yield performance of the new vs. local varieties. New varieties include IR-8, IR-5, C4-63, and BPI-76. The most commonly planted was IR-8; during the wet season of 1968 only 12 out of 127 adopters planted new varieties other than IR-8.

The major shift to IR-8 occurred in the wet season of 1967 which was the first time that the seed became available in large quantity. Official government statistics show that over 428 thousand hectares or 13 percent of the riceland in the Philippines was planted to this variety during the 1967/68 crop year.

Mr. Barker is with the International Rice Research Institute (IRRI), Los Baños, The Philippines.

Table 1: Adoption Pattern for New Rice Varieties on 155 Farms, Laguna, Philippines, 1966 to 1969

	1966	1967		1968		1969
	Wet	Dry	Wet	Dry	Wet	Dry
Area planting new varieties (%)	1	8	55	53	75	67
Farms planting new varieties - total						
Farms planted (no.)	4	14	70	62	87	69
Farms irrigated (%)	100	95	83	88	90	93
Number full-adopters	1	9	60	62	83	63
Yield/hectare - full-adopters	4,360	4,710	4,220	3,480	3,340	--
Farms planting new varieties - first time						
Farms planted (no.)	4	11	57	14	11	1
Farms irrigated (%)	100	92	80	45	67	50
Number full-adopters	1	7	47	12	9	2
Yield/hectare - full-adopters	4,360	4,530	3,300	2,770	2,820	--
Farms planting no new varieties						
Farms planted (no.)	96	86	30	38	13	31
Farms irrigated (%)	79	78	68	66	84	79
Number non-adopters	149	134	47	56	19	43
Yield/hectare	2,376	2,420	2,110	2,990	2,770	--
Total Farms planting rice (no.)[a/]	155	155	155	147	146	138

a/ Some non-irrigated farms have shifted out of production in certain seasons and nine farms were converted into housing subdivisions in 1968.

For the farms surveyed, 146 out of 155 had planted IR-8 in at least one season by the end of 1968.

A seasonal pattern has begun to emerge. A larger number of farmers are planting new varieties in the wet as compared with the dry season. During the dry season local varieties will respond to medium input levels of nitrogen without lodging. This strategy of choosing separate wet and dry season varieties seems particularly appropriate on those farms with limited or uncertain dry season water supply. Farm operators in this situation can ill afford the risk associated with the high levels of fertilizer input needed to maximize profits for IR-8 during the dry season.

Another interesting observation from Table 1 is that the yield of farms planting new varieties has decreased as the number of adopters has increased. Yields are presented only for those farms planting 100 percent of their land to new varieties, and can be compared with yields of those planting local varieties shown at the bottom of the table. As more and more farmers switched to new

varieties, both the farm resources and the levels of irrigation of the later adopters were considerably lower.

While the yield of the new varieties has shown a downward trend, the yield of local varieties has increased. During 1966 and 1967, farmers were planting nine local varieties including Malagkit, but by 1968 the latter variety predominated. Malagkit is a glutinous rice not consumed regularly in the household but used in specialty items, which received a price approximately double that of IR-8. This price, although lower in 1968 than in 1967, was still high enough to accord the variety a higher level of management and care than has been customary with other local varieties.

A Comparison of Returns and Costs

How profitable is it to grow new varieties? Table 2 compares the returns and costs for IR-8 and local varieties in the 1967 and the 1968 wet seasons. Considering first the physical relationships, there was relatively little change in resources used for IR-8 between the two years. The somewhat lower yields for IR-8 may be due to the fact that later adopters appear to have somewhat poorer water resources. Also, the early adopters of IR-8 with the superior resources had already begun to shift to other new varieties or to glutinous rice. Only nine of the 23 early adopters were growing IR-8 exclusively by the wet season of 1968.

Table 2: Comparison of Returns and Costs for Selected Rice Varieties on Farms in Laguna Province, Philippines, 1967 and 1968, Wet Season

(Values in Pesos: P = $0.256)

	Wet Season 1967		Wet Season 1968	
	IR-8	Local[a]	IR-8	Malagkit[b]
Number of farms	59	44	30	15
Physical inputs				
Farm area (ha)	2.4	2.4	2.4	1.6
Nitrogen (kg/ha)	75	20	78	56
Labor (man-days/ha)[c]	76	50	69	58
Cash costs				
Fertilizer (P/ha)	99	30	92	63
Insecticide (P/ha)	19	5	24	11
Weedicide (P/ha)	8	9	10	7
Yield of rough rice in (Kg/ha):	4,310	2,110	3,700	2,820
Price of rough rice (P/kg):	0.32	0.48	0.28	0.53
Gross return (P/ha):	1,372	1,008	1,050	1,504
Variable costs (P/ha)[d]:	406	295	475	458
Return above variable costs (P/ha):	966	713	575	1,046

a/ Includes Malagkit, Binato, Intan, Wagwag, Surigao, Milagrosa, Raminad, Tjeremas, and Pilingbaybay.

b/ A glutinous rice used in specialty items.

c/ Pre-harvest only.

d/ Includes fertilizer, insecticides, hired labor, seeds, and harvester's share.

As pointed out earlier, the concentration on glutinous varieties to the virtual exclusion of other local varieties resulted in an increase in input levels and yields. The most striking change was in the level of fertilizer use. As a consequence of better management and higher input levels, yields were noticeably higher for glutinous rice in 1968 than for local varieties in 1967.

This reallocation of farm resources between years reduced appreciably the yield gap between local varieties and IR-8. At the same time, the concentration on Malagkit tended to widen the price differentials even though the price of Malagkit declined from the previous year. The effect on income of this resource shift is shown in the last line of Table 2. In spite of lower prices for IR-8 in 1967, returns above variable costs were still appreciably higher than for local varieties. However, by 1968 the higher price received for Malagkit more than offset the yield differentials between Malagkit and IR-8.

Conclusions from the Philippine Farm Experiences

Judging from the reports received from other countries, the experience of these Philippine farmers is not an isolated case. The early adopters, usually farmers with better resources and management capabilities, have been in the best position to realize the yield and profit potential of these varieties. Later adopters with generally poorer water resources and lower level of cash inputs experienced lower yield increases.

Under the widely varying climatic conditions of tropical Asia, farm level success has not been uniform. For crops grown under irrigated conditions with high sunlight, the yield has been, in many cases, more than doubled. However, other farmers have found the new varieties unsuited to their particular climatic or cropping pattern, or not resistant to local diseases and insect attack.

An even more important threat to the initial enthusiasm with which the varieties were received is the prospect of lower rice prices. Prices have fallen in part because of the abundance of supply which in some regions has exceeded the capacities of drying, milling, and storage facilities. Of more direct concern has been the lower price received for certain of these varieties. IR-8 typically sells at a price 20 percent or more below local varieties in a number of Asian markets.

Farmers reflect their sensitivity to this price differential by switching back and forth between varieties looking for the combination of price and yield potential that will give the highest profits. As a consequence, progressive producers are still finding it

profitable in many situations to plant local varieties. Continued efforts to improve grain quality and disease and insect resistance will make it possible in the near future to select from a wide range of high-yielding varieties the one which best suits the particular farm situation.. No one can say at this time which of the new varieties will become popular in a given area. However, recent experience in the Philippines suggests that IR-8, the best known and most widely planted of the new varieties, may soon be replaced by others of superior grain quality.

Reasons for Spread

Factors influencing the rate and extent of acceptance of new varieties include: water control; degree of plant protection or resistance to insects, rodents, and disease; availability of complementary inputs including seeds, fertilizer, chemicals, and credit for capital; relative advantage of new over existing varieties, particularly in economic terms; acceptability of the quality of the new grain; the quality of the farm management; the farm institutional structure; the availability of adequate market resources including drying facilities, storage warehouses, and milling equipment; and government institutional structure, incentive, and initiative.

It is impossible to single out any one of these series of complementary factors as most essential or critical. That the spread has been more rapid than initially anticipated by many observers seems to point to the advantage of the new plant type over existing indica varieties throughout a wide geographical area in the tropics. Another unusual feature relating to the initial acceptance has been the initiative and apparently successful promotional efforts undertaken by a number of governments which in the past have shown relatively little interest in agriculture.

It is too early to determine the extent of adoption that will occur in a given country, since the dissemination process has just begun. However, five of the nine factors listed above have been used as a basis for subjectively determining which countries appear to have more favorable, average, and less favorable conditions for adoption. The analysis is presented in Table 3. Those factors which appear particularly important in influencing the initial acceptance in a given country are underlined. Among the five factors, disease resistance and acceptability of grain quality can be overcome in a comparatively short time by further work in varietal improvement and are thus more temporary obstacles to expansion than, for example, poor water control.

The contrast between the more and less favorable situations can be seen by comparing West vs. East Pakistan. The very factors

which favor West Pakistan—high yield response due to the dry climate, water control, and a minimum of disease and insect problems—are major handicaps in East Pakistan. Much of East Pakistan's rice growing area floods with the annual monsoons. Disease and insect problems have made it virtually impossible to grow IR-8 during the main crop season.

Table 3: Position of Asian Countries with Respect to Five Factors Influencing Dissemination of New Indica Rice Varieties, 1968[a/]

	FACTORS				
	Water Control	Availability of inputs	Yield advantage over existing varieties	Disease Resistance	Quality acceptability of new rice grain
More favorable:					
India	Average	Good	<u>High</u>	Average	Average
Malaysia	<u>Good</u>	Good	High	High	Poor
Philippines	Average	Good	<u>High</u>	Average	Average
West Pakistan	Good	Good	<u>High</u>	High	Average
Vietnam	Average	Average	<u>High</u>	Average	Average
Average:					
Ceylon	Good	Good	Low	Average	Average
Indonesia	Average	Poor	Medium	Average	Average
Less favorable:					
Burma	Poor	Poor	High	Average	Poor
East Pakistan	<u>Poor</u>	Average	High	<u>Low</u>	Average
Thailand	<u>Poor</u>	Average	Medium	Average	<u>Poor</u>

a/ Those factors thought to be particularly important in influencing the initial rapid or slow rate of adoption are underlined.

The new rice varieties will shift the absolute advantage in rice production throughout Asia, with water control a major factor. The lowest-cost-producing areas are likely to be those which combine a relatively dry climate with adequate irrigation, such as West Pakistan. If marketing facilities are adequate, these regions should become net exporters of rice. The traditional Asian exporting countries, Burma and Thailand, may find increasing competition on the world rice market.

[Excerpted from "Economic Aspects of High-Yielding Varieties of Rice with Special Reference to National Price Policies: IRRI Report," a paper prepared for the Thirteenth Session of the FAO Study Group on Rice, Manila, 20-27 March 1969, pp. 4-7 and 9-10.]

Mobilizing Capital to Sustain the Agricultural Revolution

Stanley Please

[If agriculture is to grow more rapidly, significantly more resources must be mobilized to this end. Some of the ways in which this could be done are: increased taxes on agricultural incomes, reduced subsidies on agricultural inputs, and higher interest rates for private savings.]

Estimates of the effects of rising population levels and rising per capita incomes through 1975 indicate that at a minimum, the demand for food will rise by 3.2 percent annually, and at a maximum by 3.9 percent—according to the Food and Agriculture Organization of the United Nations (FAO). Actual rates of growth of food and agricultural output in recent years are about 2.8 percent. If, therefore, the rate of growth of agricultural output is to keep pace with the higher of the two rates of growth of food demand, the annual addition to output must be stepped up by almost 40 percent.

Our analysis suggests that the investment needed to generate this increased rate of growth of output will require the mobilization of additional resources equivalent to between 3 and 8 percent of the existing level of investment funds in the developing countries as a whole. These numbers indicate that the resource problem is quantitatively significant in terms of the policy changes needed if these resources are to be mobilized. Additional resources will have to be found from within the agricultural sector itself, from other

Mr. Please is Chief of the Domestic Development Finance Division, Economics Department, International Bank for Reconstruction and Development, Washington, D. C.

sources within each developing country, or from the developed countries.

Most of my discussion will be in terms of and illustrated by the experience in India and Pakistan. Here lives over 40 percent of the population of the developing member countries of the World Bank, and it continuously hovers on the brink of physical starvation. Although the institutional setting varies enormously from country to country, the major problems and policy questions which arise in India and Pakistan have, I believe, their parallels in most other countries.

Effects of Prices

A growing body of empirical evidence confirms that within the agricultural sector itself, cultivators are very sensitive to changes in the relative prices of different agricultural products—rice as against jute in East Pakistan, cotton as against karakul in Afghanistan, rice as against cotton in the United Arab Republic, etc.

Regarding the price sensitivity of total agricultural output, what little evidence is available confirms that total output does respond positively to an improvement in agriculture's terms of trade. Higher prices not only provide the incentives but also the wherewithal to increase output. The latter is more important; higher prices enable farmers to invest more heavily in land clearance, tractors, fertilizers, wells, pump sets, and all the other inputs which constitute the agricultural revolution. Not only are they able to invest more heavily, but they are also more willing to do so when profitable investment opportunities exist and the physical inputs are available.

The evidence on this question is fragmentary rather than systematic. In both Pakistan and India farmers have been investing heavily over the past five years in private tube well construction largely, it would appear, out of their own funds. The Bank's study of the Water and Power Resources of West Pakistan argues that: "The availability of tube well equipment in itself represented an opportunity for investment which would not otherwise have been there; this opportunity in turn encouraged interested farmers to save." Likewise there frequently appear to be adequate funds in private hands for the purchase of available supplies of tractors, fertilizers, new seeds, etc. A similar situation has existed in India in recent years.

Savings data do not permit us to judge whether these funds have merely been diverted from other investment outlets or whether they reflect a reduction in what would otherwise be expenditure on consumption—more elaborate weddings, etc. However, previous analyses of capital flows within Pakistan show a large unexplained

residual net outflow of private savings from the agricultural sector. It seems probable that this outflow has been curtailed because of increased profitability of agriculture, with cultivators showing increased preference to invest in their farms. In addition, private savings from the non-agricultural sector have probably begun flowing into agriculture, as is borne out by the reports of investment by industrialists, civil servants, army officers, and professional men in farming both in Pakistan and in India. The impact of these developments is at the moment limited to a small part of the agricultural sector and is unevenly spread geographically. Nevertheless, the capacity and willingness to save on the part of the agriculturalist is extremely important.

The higher the food prices, and the lower the prices of agricultural inputs, the greater will be the incentives to employ the most advanced technology and to produce for the market. Too often, farmers have been offered prices much lower than the value of their output. On occasion the disincentive effect of low prices has been partly offset by subsidized inputs, but these small favors have been applied haphazardly. The Bank has been pleased to note, however, that the importance of the food price problem is becoming recognized in developing countries and that the trend has been towards more realistic output prices. The level of output prices received by the farmers should be kept under constant review.

Government Financing of Agricultural Investment

The additional investment in agriculture will require the mobilization of additional resources by the government, both to pay for infrastructure and to support financing of farmers' investments out of budget funds channeled through agricultural credit institutions.

The authorities must look to the generation and/or diversion of public savings if the internal financial needs of the agricultural investment program are to be met without expansionary financing through the banking system. In principle, funds may be derived from: an increase in tax burden on the non-agricultural sector; a reduction in current non-development expenditure; and a curtailment of investment outlays in the non-agricultural sector. But experience in recent years suggests that the likelihood of action along any of these lines is either not very great, or in some cases not even desirable. Some curtailment of non-agricultural investment is possible, but much of this would cut into activities which are complementary to the agricultural sector—maintenance of feeder roads, electrification schemes beneficial to agriculture, fertilizer investment, etc.

In effect, increased investment in agriculture should, as far as possible, be additional investment in the economy and not simply

displace other investment. But this means that domestic savings must be increased. The chances of achieving this through the budget are slight unless governments show far more willingness and ability to reduce the level or even the rate of growth of their non-development expenditure than has typically been the case. The question then becomes one of determining the sectors upon which an increased weight of government revenue generation should fall.

The combined effect of increased productivity resulting from the employment of the new technology, and of improved terms of trade for agricultural producers, has been to increase their incomes. It is apparent that it has also widened rather than reduced income disparities. Against this impact must be seen the relative failure of governments to ensure that some significant part of the incremental incomes are mobilized for financing further development. It is a failure on the one hand to tax the agricultural sector to the extent of other sectors of the economy or to the extent that is economically possible, and on the other hand, a tendency to provide fiscal subsidies to the sector through the underpricing of irrigation water, electricity, credit, fertilizer, seeds, pesticides, etc.

In India and Pakistan the rates of land revenue taxation have remained virtually unchanged for decades so that revenue from this tax is now only about one percent of the net output of agriculture. The state and provincial governments have failed almost completely to tax agricultural incomes, although the national governments have markedly increased the income tax rates on non-agricultural incomes. Revenues from irrigation rates, rural electricity charges, fertilizer sales, etc., have failed to rise with the costs of these goods and services, so the fiscal subsidy to agriculture has grown. In India the subsidy through irrigation rates alone represented more than 40 percent of direct tax revenue derived from agriculture in 1966/67.

The strongest attack on the problem of raising increased resources for financing agricultural development must be to increase the taxation of the agricultural sector itself. It must be remembered that the part of the agricultural community which is benefiting from the agricultural revolution is not the subsistence farmer with two or three acres of land but the medium and larger farmers, representing no more than 5 percent of total farm families. The tax system must not dull the incentives to this dynamic part of the farming community, but neither must the government feel the sense of social responsibility to these larger farmers which it might justifiably show to the smaller ones.

Given the political difficulties which countries like India and Pakistan have experienced in increasing land taxes and income tax on agricultural incomes, a less direct frontal assault on the problem

should be considered. One way would be to weight the structure of indirect taxes on consumer goods so that they fell more heavily on those consumed by the agricultural community. Our studies of Pakistan household budget data have not suggested much scope for action along these lines, however, as the farmers' consumer goods are not clearly differentiated from others. A second possibility is to reduce the subsidy on agricultural inputs. Increments to agricultural output largely result from the use of more inputs of water, fertilizers, insecticides, etc., so the consumption of these inputs can be used as a proxy for increased output.

One aspect which is of very great importance is to know, for each commodity, to what extent the expansion of the demand for an input must depend upon the breaking down of traditional attitudes of farmers by (perhaps temporary) reductions in price below cost. In India, for example, water is an accustomed input, the importance of which is already widely understood by the farmers, so that increased water charges should have no disincentive effect. In the case of fertilizer, plant protection and improved farm machinery, the situation is less clear. In some countries or regions new habits clearly need to be built up; on the other hand, the existence of black market prices for these inputs from time to time and from country to country suggests that availability rather than effective demand is often the constraint on an expansion in utilization. When this becomes clear on a national scale, then such inputs need no longer be subsidized and may even become ripe for taxation.

A stepped-up investment program in agriculture, and specifically in food production, cannot be financed readily unless the contribution of farmers to government-generated investible funds is increased. This conclusion is important from a tactical-political point of view. Farmers the world over are afraid that their tax payments might be used by city-based governments for purposes other than the development of the agricultural sector. It may be necessary to break through this suspicion by linking any increased tax imposition upon them to expenditure proposals beneficial to the agricultural sector, even at some sacrifice of budget flexibility. Earmarking is a device used widely in some countries (e.g., Latin America, the Philippines, French-speaking West Africa) but not in others (notably India, Pakistan, and other ex-British colonial countries). The political situation in the latter countries might make resort to this device essential.

Mobilizing Private Savings for Agricultural Investment

In principle financial institutions should be concerned with mobilizing private savings and allocating them in the most efficient manner between sectors, firms, etc., within the economy. In fact, the

emphasis in most developing countries has been to ensure that these institutions make available a supply of cheap funds to favored borrowers—particularly to the public sector itself and to agriculture. The government has taken the view that in some sense farmers are "entitled" to low rates of interest and other concessionary terms on their borrowing from financial institutions. This attitude may be ascribed to an over-reaction to "usurious" interest rates charged by lenders in the unorganized market.

The attempt to keep interest rates low to borrowers becomes exaggerated by the rises in prices which have taken place in most developing countries; a rise in prices, of course, effects a fall in the real interest rate. In the somewhat extreme case of Brazil, the effective real rate of interest on commercial bank loans (i.e., including hidden commissions, etc.) has been negative almost continuously since the early 1950s. But even for a country like India, with a record of price stability which is unlikely to be bettered if development is not to be sacrificed, the annual average increase in prices over the past decade has been between 6 and 11 percent. Thus with borrowing rates over this period of around 5 percent for the public sector, 8.5 percent for agricultural borrowers from Land Mortgage Banks and 9.5 percent for commercial bank advances, real rates of interest have been around zero for most and definitely negative for the public sector.

In a country which is short of investible funds relative to investment demand, a real interest rate around zero will hardly result in the most efficient utilization of such funds. More important, if the lending rates of the financial institutions are kept low then, in the absence of subsidization on any adequate scale (as, for instance, in Korea) borrowing rates paid to depositors must also be kept low. When savings must be mobilized by the organized institutional sector, then the gap between the little that this sector can offer its depositors and the alternatives available from the unorganized market, from foreign investment or from precious metals, becomes critical. Empirical evidence for India and Pakistan certainly suggests that the growth of commercial bank branches is linked to the growth of deposits, and that this holds not only for unbanked areas but also for those already banked. The creation of new branches and the process of generation of new deposits is costly, and these costs cannot be met if the bank net revenues are squeezed below an uneconomic ceiling on their lending rates. So the growth of an efficient banking system to serve rural areas is frustrated, and a similar situation confronts the insurance companies.

Other concessions to agricultural borrowers are important in certain countries: unduly low contributions by borrowers out of their own resources, together with long repayment periods, are

commonplace in agricultural lending. In repayments, there are high levels of overdues, large proportions of which are probably irrecoverable. All these concessionary elements indicate a "soft-hearted" attitude towards agricultural borrowers, and an attitude towards the resource mobilization problem which does not reflect the seriousness the siduation demands.

This attitude is likely to prevail as long as the lending institutions are deriving their funds at concessionary terms from the government or the central bank. The serious resource position can only be made to register with bankers if the real cost of the resources they receive is made clear to them. This is most likely to be achieved if the institutions are forced to be responsible for mobilizing some large part of their own financial needs, rather than drifting in the belief that this is the responsibility of government, central bank, etc.

The national authorities must now pay more attention to the use of financial institutions as mobilizers of financial resources in and for the agricultural sector. Voluntary private savings are bypassing the organized financial institutions to seek higher returns elsewhere; or the funds are being consumed. By implication, they are being used for lower priority purposes and less efficiently than if they were mobilized by the organized financial market and more effectively channeled into the new developments in agriculture. There must be a revision of the level and structure of real interest rates to savers and, in the absence of subsidies, to borrowers also. Where the financial returns to investments in tube wells, tractors, fertilizer, new seeds, etc., are recognized to be high, there is no justification for making funds available at very low or negative interest rates.

External Assistance to Support the Agricultural Revolution

The ability or inability of countries to sustain the agricultural revolution will primarily depend upon their own exertions and their willingness and ability to take crucial policy decisions to mobilize the resources required. These will not be easy decisions to make. This makes it all the more important that aid-givers support those countries which are taking their responsibilities seriously in this regard. For while the weight of responsibility falls on the governments of the less developed countries, their efforts will be less successful if the catalytic effect of foreign assistance is not available, or is unavailable in adequate amounts and at appropriate times.

There is no up-to-date estimate of the level of aid required to support investment in agriculture. According to the Organization

for Economic Cooperation and Development, such aid amounted to almost $1 billion in 1965, which represented 12 percent of bilateral and 20 percent of the multilateral assistance. . As the agricultural revolution in developing countries gains momentum, the requirements for foreign aid are likely to be large. In a sample of World Bank projects which we have examined, the foreign exchange component represents on average 40 percent of total project expenditure.

Governments could make foreign exchange available to support their agricultural programs through an improvement in their balance of payments positions on current account, or from a redirection of their existing capital inflows towards projects in the agricultural sector. The scope for achieving the required additional foreign exchange in these ways is, however, limited. Undoubtedly the way in which to make certain that the agricultural revolution is not held back through a shortage of foreign exchange is for the volume of foreign assistance assigned specifically to this purpose to be increased but not at the expense of other kinds of assistance; total foreign aid should increase. This is certainly the conclusion which we, in the World Bank, have drawn in terms of our own lending strategy.

The evidence is strong that when the supply of fertilizers, seeds, tractors, etc., is increased, the willingness of the agricultural sector to save or to divert existing savings into agricultural investment is likewise increased. The common assumption of all economic plans that domestic savings are determined independently of investment opportunities must be seriously questioned. In doing so we must then recognize that the extent of these investment opportunities in agriculture will be determined in no small measure by the availability of increased foreign assistance, for it is only in this way that some of the essential ingredients of the new agricultural technology can be obtained.

[Excerpted from "Capital Flows and Income Transfers within and between Nations to Sustain the Agricultural Revolution," a paper given to the Conference on Agricultural Development, sponsored by the Rockefeller Foundation, in Bellagio, Italy, 23-25 April, 1969, pp. 1-15.]

Social and Political Implications of the new Cereal Varieties

Jerome T. French and Princeton N. Lyman

[Handled indiscriminately the high-yielding seeds have the capability of increasing economic disparities and thus augmenting social frictions and political instabilities. But they also offer possible new contributions toward solving problems like malnutrition and land reform.]

Rarely in history has progress been achieved or change occurred without some benefiting more than others; some degree of stress, and often violence, has accompanied it. Stress and disparity can often be ameliorated, however, if we are alert to the problem and anticipate the areas of trouble.

An anticipatory analysis of socio-economic changes arising from the high-yielding varieties (HYV) programs prepared by Edward Rizzo of the U. S. Agency for International Development (AID), is quoted here. It was based on limited data, mainly in India, but conforms in its conclusions to the materials now available from other areas with a few exceptions to be noted later.

> Where the introduction of HYV meets with initial success both in terms of farmer profit and production technology, there is a tendency for the adoption to spread to more land, on more areas. Among the farmers in a given area, the income-distribution will tend to polarize. The richer and larger farm-owners will gain more profit and faster than the poorer, smaller

Messrs. French and Lyman are Political Scientists with the Title IX Division, U. S. AID, Washington, D. C.

farmers. A study made of three Indian villages shows that 55 out of 209 farmers (26 percent) adopted the high-yielding varieties. These farmers tended to have the following characteristics: more acres cultivated; more agricultural production; higher percent of crops raised were sold; more kinds of crops raised; more rupees return per day of labor input (more efficient); more land owned; younger farmers, with higher education, and higher level of living; more participation in formal organizations; more urban contact and secular orientation. It does not take much imagination to see emerging a profile of a farmer elite group.

Politically, these farmers will tend to become an interest group pressing for more credit, better irrigation, more fertilizer, more seed, a better distribution system, more favorable prices from the buyers, etc. Politicians seeking rural support may link themselves to these rising interest groups and press for agricultural price supports, irrigation projects, etc. Political balance between industrial and agricultural interests will change—and may be reflected in political parties and legislatures.

In the local area, those farmers who do not adopt HYV may find themselves without a market. It may mean serious crop loss for some. Others may find it more profitable to leave their farm and become laborers on those farms using HYV, thus widening the economic spread.

As farm incomes rise, new demands will arise for capital and consumer goods. This will stimulate local suppliers to expand production or attract suppliers from other areas. As expectations rise regarding next year's income and production possibilities, however, the HYV farmers will tend to become over-optimistic. This same psychology may affect other farmers, suppliers of the farm markets, and rural migrants who see good times ahead. If this bubble bursts by failure in any part of the system—sale prices, storage, cost rises, lack of government support, etc. —it may have a boomerang effect on the HYV.

HYV will tend to be concentrated in certain ecological areas, and within such areas certain local communities will tend to spurt their production ahead of others for a variety of reasons. The same phenomena that occurs within a socio-economic area is repeated between such areas. The market may be flooded by production from some regions and depress others who lose their markets. The gap in farmer income, labor supply, infrastructure investment, etc., will tend to grow

between regions. This may have political repercussions, as representatives of the less-well-off regions strive for a larger share of the wealth and call for more government assistance to compensate for the imbalances. Where there are tenous alliances and balances of interests, there may be significant shifts.

This analysis only skims the surface of social and political consequences. Some of the problems inherent in these changes are not likely to blow up to crisis proportions for perhaps a generation or more, and yet in a generation they may be too far advanced to solve.

Evidence on the Differential Benefits of HYV

There is clearly a trend towards disparity in benefits from HYV. In Mexico, in areas where improved varieties have been adopted it has been by the larger growers. The poor growers have largely been by-passed because the larger growers could use their greater access to the required water and irrigation systems to capitalize on new varieties, and because preferential treatment was shown them by the government. It might be said that the Mexican program has been most successful in that overall production has increased to the point where massive imports are no longer needed; indeed, the nation is faced with the problem of finding export markets for surplus production. But on the other hand, large segments of the rural population have not benefited from the fruits of technological progress. Work has been initiated to help rectify this situation, but it may be some time before it begins to pay off for the small farmer. And in any case, the overall market for the small farmers' product will not be bolstered by the already heavy supplies coming from the large producing areas.

This pattern may be repeated in Morocco. The Moroccan wheat improvement program is directed primarily at farmers in the traditional sector who have more than 10 hectares (55,776 out of 1,050,989) and are located in rainfall zones of at least 300mm; plus farmers in the "modern sector" whose holdings are over 500 hectares, and who number only 121,000. Thus over 80 percent of Morocco's farmers are not participating in the program, and they are also the poorest. Since all inputs other than water in Morocco (and perhaps this too) seem to be heavily subject to government control one is left with the conclusion that, as in Mexico, government policy and water are the critical variables.

In other countries size of holdings and access to water are also important, but other factors enter the picture and disparities are less dramatic. In India, for example, a survey shows that both large and small holders have participated with HYV and that small

size of holdings was the reason for non-participation in only 17 percent of the cases studied. Nonetheless other reasons cited, including the most common one (inadequate irrigation—58 percent), were those most likely to present a problem to small holders. In Turkey, failure of small farmers to benefit proportionately is ascribed to differential availability of technical inputs and credit.

In Pakistan, data indicate that owner-operators regardless of the size of their holdings have tended to adopt HYV more rapidly than non-owners or tenants. This correlates with other data, not directly related to the high-yield varieties, which indicate that owner-farmers whose holdings are generally considered too small to be economical will actually be more innovative and productive than large absentee holdings when proper incentives and opportunities are available to them. Nonetheless, in Pakistan as elsewhere, experience suggests that high-yield varieties catch on quicker with larger farmers who are in a better position to adopt new practices. This is one factor in the disproportionate participation between East and West Pakistan, since there are few comparably large farms in East Pakistan.

There are also indications that some groups may suffer absolutely as a result of the introductions of high-yield varieties. Small farmers, tenants or farm laborers, for instances, may be displaced. In Pakistan, in farming areas where Mexican wheats and other improved practices have resulted in large yield increases, there are an increasing number of instances of the more progressive farmers purchasing additional land, squeezing out smaller farmers who have not adopted new practices. Land prices have increased due to the higher income obtainable from the new varieties. In addition, there is a small but definite movement of eager landlords or their sons back to the farm to begin direct cultivation of their family lands, sometimes displacing tenants.

Position of Farm Labor

The impact on farm labor trends is decidedly mixed. In some instances (e.g., Turkey, India and Pakistan) a trend towards increased mechanization of agriculture, particularly with regard to the new wheat varieties, has been noted, with potentially negative consequences for labor-intensive agriculture. In other instances, sometimes in other parts of the same countries, increased labor per hectare has been required. This holds for both wheat and rice. Higher yields, coupled with scarcity of machines and the fact that labor becomes at certain times a crucial factor during particular phases of the production process, has considerably altered traditional relationships between farmer and agricultural laborer, greatly strengthening the bargaining position of the latter. The implications of this have thus far not been fully realized.

There has been one well reported example of the kind of problems which may emerge. It is always dangerous to generalize from a single case, but there are sufficient similarities in other situations to warrant more than passing reference to recent events in Tanjore District of Madras State in India. There, on the night of December 25, 1968, 43 peasant families, mostly women and children, were burned to death when their village huts were set on fire in a clash between landless farm laborers—from castes traditionally considered untouchable—and a mob of 300 led by higher caste landowners. The issue was higher wages related to the new varieties. This was not a situation in which some were benefiting and others were not. All parties were better off, but some were benefiting relatively less than others. The importance of the role of labor in the production process had increased considerably, creating a situation in which laborers were in a far stronger bargaining position with their employers. These new factors interacted with existing circumstances in such a way as to upset the status quo and create a volatile situation.

Other Adverse Possibilities

Regional disparities are already the source of great friction in Pakistan, India, Nigeria and other countries. To accentuate these differences by establishing entrenched socio-economic disparities protected by important political ties, and subsequently by government policies allocating subsidies and other resources to maintain these disparities, will only deepen antagonisms and make them harder to redress. If participating farmers in HYV programs are becoming a more vocal and influential interest group, this is a good thing for them and perhaps generally for the rural sector, but it must be balanced by larger public considerations. What is the effect of their new influence on the interests of others not yet vocal?

A second area of concern, related to the first, is the direct political consequence of a suddenly growing disparity of wealth. We do not know too much about causes and conditions of rural political participation, but there is evidence which suggests that inequalities in the presence of relative wealth are more conducive to discontent and dissent than straight poverty. Sharply changing conditions of rural production and income caused by the HYV, even when all in the area participate to some degree in the new prosperity, may be conducive more to widespread rural politicization than to passivity. This politicization—desirable as it may be in terms of popular government—may turn destructive rather than constructive, as in the case of the Tanjore incident cited above.

Third is the area of price supports and other methods of economic favoritism. Many countries may be led down the path of high price

supports that become an important element of political alliance between particular rural interests and political parties or groups. The support levels may become in time so uneconomic as to endanger the stability of the economy, but governments may be too weak to move away from them. Not a few governments in the less developed countries (LDCs) have become prisoners of such politically organized economic groups, or economically inefficient financial policies, and their inability to break loose from them when economic stability is threatened has been one justification for military or other forms of authoritarian rule.

Finally, there are the long-range problems that get pushed aside because their dangers are not manifest. Heavy rural-urban migration often has a one or two generation gap before its results are politically manifest. Introduction of the HYV in a way that greatly increases this migration will force countries to pay a heavy price. In some of the LDCs we are talking not about minorities unable to be absorbed amidst huge industrial progress and rolling farms, but near-majorities who are being by-passed by the changes and who may be forced into cities already unable to meet the needs of existing residents.

Opportunities

Despite its dangers, the Green Revolution presents striking opportunities to help solve problems for which there had been no solution in sight.

Land tenure. Evidence indicates that landowners of all sizes are receptive to participation in HYV programs where the opportunities to do so exist. HYV technology offers new possibilities for strengthening the position of small farm owners, and not only those now in existence but also those created by future land redistributions. If, in approaching the sensitive and politically critical problem of land reform, a government tied HYV credit loans, fertilizer loans, etc., to programs of new land distribution and land tenure so as to make HYV a basic support for small farmers, it would give such programs a new kind of security. In this way it could support a political reform, criticially needed in many areas in the writers' view, with the needed margin of economic and technical efficiency.

Rural vs. urban population trends. The rural-urban migration in the LDCs cannot be stopped, but it might be slowed. HYV are in some cases relatively labor-intensive. In India, for example, labor shortages were reported for both wheat and rice production; mechanization seems like the easy way out. But in India, Pakistan and many other countries this would be a prescription for disaster that will later outrun its production benefits. By contrast, a combination

of policies that emphasized land ownership and secure tenure for small farmers, or organized and well regulated labor conditions for large farms using labor-intensive methods, would ensure not only production increases but some attractiveness to people in staying in the rural areas.

Hunger and malnutrition. Because of the tremendous increases in food output from the new varieties, many farmers are undoubtedly consuming more, as well as selling more. Widespread famines may be now preventable in almost all countries. But we need to remember that the distribution facilities remain underdeveloped, so that many less-favored groups are unable to share in the new bounty. What are needed are innovative approaches to new technology in transport and distribution in order to lower costs, improved crop diversification programs, international agreements on "food banks" to meet famines, and many other scientific and policy breakthroughs, so that the promise of increased nutrition may become a reality.

Deeper Problems of Agricultural Assistance

Technical experts in production tend to feel that problems related to distribution are the problems of other people, i.e., of economists and social scientists as well as political leaders. However, these "others" may also lack the skills or the feeling of priority in this field, so that the specialization of responsibility is both false and dangerous. It is precisely our failure to look at development processes as a whole (without slowing down the technological advances) that keeps economic and social response well behind the technological, while making technological advances as much a danger as an aid.

The deeper problem is that most modern technicians do not really believe that small, labor-intensive farms are a feasible solution for any country's rural development. Despite statements to the contrary and support of some important programs aimed at small farmers, Western advisors by and large welcome and are happy to support agricultural development programs that strengthen large mechanized commercialized holdings vis-a-vis small family ones; support concentrating innovative practices on the larger farms; and generally oppose land redistribution as a central element of agrarian reform on the grounds that it is better to improve the larger holdings than create "inefficient" small ones. Bias in this direction leads us to discount the success of both Japan and Taiwan with production increases from intensive agriculture, and to discount evidence from Latin America that absentee-landlord holdings are often the most inefficient farms, while small holdings and land redistribution can be consistent with production increases.

This technicians' bias is a dangerous one. Whatever the productive efficiency of large, mechanized farms, they are not efficient in the larger sense for countries like India and, indeed, most of the other LDCs. American experience is totally irrelevant to countries jammed with millions of people in the rural areas and with only fledgling industrial structures. Copying the American model, in fact, would create social and political problems of destructive magnitude.

What we need is a commitment to developing a new technological approach, to be worked out by agricultural technicians and supported by agricultural universities, economists and social development analysts and administrators. There is a real lack of knowledge: development advisors simply do not know enough about effective means for reaching large numbers of small farmers with information and incentives, for making intensive agriculture more productive, and for providing adequate economic support and social services to this type of rural economy. Yet it is in developing effective and, where needed, totally new technologies that we in the advanced countries should be able to make our greatest contribution to the LDCs.

[Excerpted from "Emerging Problems: Social and Political Implications of the New Cereal Varieties," Spring Review of the New Cereal Varieties. Washington (D.C.): U.S. AID, 13-15 May, 1969, pp. 1-25. Unpublished report.]

Increasing Opportunities for Mechanization

Lyle P. Schertz

[The introduction of high-yielding varieties of wheat and rice brings the possible gains from mechanization—the use of tractors, power tillers, irrigation pumps, and related equipment—sharply into focus. Developing countries are reexamining their thinking on farm mechanization; for some this will mean venturing into a previously neglected area.]

Efficient plowing with moldboard plows, drilling of seed to uniform depth, and placing of fertilizer at optimum location in relation to the germinating seeds, have a much larger impact on the yields of high-yielding varieties than on the traditional varieties with a much lower potential yield. The much shorter growing season for the new varieties means that in many cases they will ripen during rainy periods. These possibilities create a need for threshing equipment that can efficiently harvest grain high in moisture, and other equipment that can quickly dry it. For example, the IR-8 rice being introduced into Southeast Asia matures in 120 days in contrast to the 180 days required by the older native varieties.

This shorter growing season of the new varieties, and their ability to mature without regard to day length, make possible double and multiple cropping. Thus, as soon as the first crop of rice is harvested, another may be planted, to be followed by still another, if water is available and if harvesting, land preparation, and planting are done quickly. Alternatively, sorghums, wheat or potatoes can be planted

Dr. Schertz is Assistant Administrator, International Development, Foreign Agricultural Service, U.S. Department of Agriculture, Washington, D.C.

after the rice is harvested; or they may be interplanted among the rice crop before rice harvesting. Tests at the International Rice Research Institute show that IR-8 rice, followed by grain sorghums permitted to ratoon (sprout) two times, has produced over 20 tons of cereals per hectare in 365 days, some three times the average U.S. corn yield. The availability of machinery may determine whether individual producers can realize these kinds of payoffs. With traditional varieties, delays in starting another crop are not important—the land would be idle anyway. But with the high-yielding varieties that can be grown year round, each day of delay means one day of lost crop production. With 120-day rice capable of yielding five tons per hectare, almost 100 pounds of paddy (rough rice) per hectare per day are at stake.

The new cereals are also sensitive to water availability. The high potential yields encourage farmers to use machinery to improve water management. Land leveling, terracing, well-drilling, and water pumping have much larger payoffs with crops having potential yields of four to seven tons per hectare than when only two tons can be realized.

Mechanization can also influence marketing. Modest increases in production mean large relative increases in the marketable surplus; where a farmer who traditionally produces 100 bushels of grain and uses 80 bushels to feed his family increases production to 140 bushels, he has three times as much surplus grain to sell. But the size and speed of ox carts limit the farmers' potential in handling a sharply increased crop.

Present Status of Mechanization

Almost 95 percent of the world's tractors are now in the developed countries. The developing countries, according to the Food and Agriculture Organization of the United Nations (FAO) estimates, had just over 800,000 tractors in 1965. The annual increase has been relatively modest—less than 40,000, or four to five percent per year. Latin America has by far the largest ratio of tractors—five per 1,000 hectares of arable land. The Far East and Africa had less than one per 1,000 hectares, while Western Europe had 42. Overall, the developing world had one tractor per 1,000 hectares; the developed world had 19.

Not only does the number of tractors vary widely but also the types in use in different areas. For example, Japan has more horsepower available per hectare of arable land than any other country, but this power is largely concentrated in small power tillers (garden-type tractors). In 1965 Japan had only 24,000 tractors but 2,500,000 power tillers, used largely in the rice paddies.

Potentials for renting the equipment to other farmers or for custom work (plowing neighboring fields for a fee) have encouraged some farmers to buy more machinery. The use of tractors in Thailand has expanded sharply in recent years. This expansion has been largely of 30-70 horsepower units, with owners often developing a large amount of custom work. One fourth of the Thai rice acreage was plowed with tractors in 1967.

Policy Considerations

Cost of mechanization. Some of the key questions are: (a) Are credits and/or savings available to farmers or cooperatives to purchase the machinery? (b) What are the availabilities and prices of imported machinery? (c) How much training will be necessary for farmers to learn to operate equipment, and for repair shops to maintain the equipment to be established? (d) Is local fuel available or must petroleum be imported? (e) How well developed is a system for supplying spare parts and making repairs, and what costs would be involved in making it effective? (f) What would be the overall effect on foreign exchange requirements?

Payoffs from mechanization can result from: (a) completing tasks with more precision; (b) accomplishing work more quickly; (c) developing resources not presently being used; and (d) accomplishing tasks not possible with traditional techniques. The probable value of gains from each of these areas needs to be carefully worked out and then evaluated in light of the above cost factors.

Political and Social Questions. Governments will need also to consider non-economic questions in resolving their policies and programs. For example, the mechanization of agriculture could widen the gap between large and small producers. Effects on labor requirements are important; some countries need to release labor from agriculture to permit industrialization, while in others the release of such labor will aggravate unemployment. Each country will of course appraise all these things differently.

Influence on Foreign Exchange Position

Most developing countries have balance of payments problems and need to evaluate mechanization policies with respect to both expenditures and earnings of foreign exchange and also its alternative uses. Thus it is important to appraise the potential effect of mechanization on production along with its cost, since increased output of an imported product could save scarce foreign exchange; and foreign exchange earning might be increased, on balance, if the crop were exported.

Some examples of increased production from mechanization may be cited: a tractor evaluation project at Allahabad, India, found that land cultivated by tractors produced significantly more than that cultivated by traditional methods; and that pumping water for irrigation occupied the largest number of tractor hours, for many individual tractors over 40 percent. Another study showed that upland rice yields in Raipur, India, were increased by as much as 40 percent through more effective preparation of fields for sowing over those methods commonly followed.

Relationship to Employment

For years it was widely thought that there is surplus agricultural labor in developing countries generally, so that removing labor from agriculture would not lower farm production; introducing machinery, then, would merely increase unemployment or underemployment of labor. Largely ignored were the importance of timing in performing tasks such as planting and harvesting at times of peak labor requirement, and some of the implications of technological change.

The seasonal labor requirements of agriculture vary widely during the planting, growing, and harvesting periods of crops such as rice and wheat. One estimate is that Thai rice farmers work 30 percent above the standard work level during the planting season, and 15 percent during the harvesting season. In the Punjab, India, when peak labor requirements occur in November, wage rates are about double their normal level. As the demand for peak season labor increases, equipment capable of speeding up the planting and harvesting would appear to be valuable to farm operators.

The President's Science Advisory Committee's Report on The World Food Problem (Vol. III, p. 213) gives estimates of the available horsepower from tractors, animals, and humans in selected countries and regions (see Table 1). These estimates point up several important factors: the total power available on the farms in developing countries, including human, mechanical and animal power is very low compared to countries such as the United Kingdom, the United States, Israel, and Japan. But, even in the developing countries, less than two fifths of the available horsepower for agriculture is supplied by humans. A substantial proportion of the horsepower used is already being contributed by capital, in the form of either tractors or livestock. For example, the doubling of human power input in India would raise it to 11 horsepower per 100 hectares, a level still 25 percent below that presently being supplied by animals.

Table 1: Available Horsepower per 100 Hectares of Arable Land and Land under Permanent Crops

	Tractors Over 8 Horsepower	Garden Tractors	Animal	Human[a/]	Total
Africa	3	---	1	1	5
Asia[b/]	2	3	10.0	5	20
India	0.8	---	14.5	5.6	21
Latin America	18	---	7	2	27
Taiwan	3	6.3	6.3	11.3	27
Oceania	33	0.6	1.1	0.1	35
United Arab Republic	18.1	---	6.5	12	37
Israel	81.5	0.7	1	1.6	85
Europe	81	2	8	2	93
United States	100	1.4	---	0.2	102
United Kingdom	157	3	2	9	171
Japan	0.4	206	8.8	14.8	230
World	26.6	2.4	4.4	2.4	35.8

a/ Estimated 1/15 h.p. per person employed in agricultural operations.
b/ Excluding Mainland China

Investments in machinery are not necessarily inconsistent with large inputs of labor. Human labor inputs in Japan, Taiwan and Egypt supply substantially more horsepower per unit of land than in India or in Asia as a whole, which in turn are more than double the human labor inputs per hectare in Europe, Latin America, and Africa. But Taiwan and Egypt also have investments in machinery substantially above levels in most other developing countries, while Japan has similar investments that are among the world's highest. In short, machinery is not merely a substitute for human labor; the two may also have a complementary relationship under the right circumstances.

The New Seeds

Positive implications for labor requirements flow from the need to develop irrigation for the high-yielding seed varieties. Even before the widespread introduction of these seeds in Asia, high returns from machinery used in the development of water avilability and in its management were recognized; today the rate of construction of irrigation wells is accelerating with the availability of the new varieties.

We need to consider effects of mechanization on labor requirements in terms of whole systems of farming, involving alternative combinations of other inputs as well. With the high-yielding seeds, pesticides, fertilizers, etc., an increase in machine-irrigated acreage could result in substantial increases in labor requirements, as indicated by the experience of Japan, Egypt, and Taiwan.

Role of Private Enterprise

Good information on the profitability of using machinery is scarce, and government officials will find it difficult to anticipate the precise types of machinery that can most economically be utilized. Agricultural diversity suggests that a variety of equipment will be required, and that needs will change as technology continues to change. Policies and programs, therefore, should not rigidly prescribe the size and type of machinery to be made available. The individual farmer is in the best position to determine which machines can most effectively increase his economic return, and he should have flexibility for private decisions in the selection of his equipment.

Many mistakes will undoubtedly be made in mechanizing agriculture—whether machinery is produced, procured and distributed by government or private organizations. Government organizations trying to avoid mistakes often restrict amounts and types of products for use, thereby missing attractive opportunities that private bodies would uncover. While research will help avoid mistakes, much trial and error will still be required to relate mechanization appropriately to the changing economic and social conditions of individual countries.

In advocating heavy involvement of private enterprise, I do not mean that governments will not have a significant role in mechanization. In working with private firms which either import or produce machinery domestically, governments can be especially instrumental in insuring that: adequate resources of the private companies are given to developing a system for availability of parts and repairs; excessive proliferation of types of machinery is avoided, without unduly stifling competition; relatively large expenditures are made on in-country research by firms supplying imports; and government research and training programs on mechanization are expanded.

[Excerpted from "Food, Man, and Machines," a statement presented at the 1968 Annual Meeting, North Atlantic Region, American Society of Agricultural Engineers, Storrs, Connecticut, 26 August 1968, pp. 3-28.]

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